HUMAN ENGINEERING THE WORKPLACE OF THE BLIND IN INDUSTRY

by

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for

NATIONAL INSTITUTES OF HEALTH
Division of Neurological Diseases and Blindness
Research Grant B-1224

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Century Research Corporation,
January 1966

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ACKNOWLEDGMENT

The authors wish to express their appreciation to members of the staff of Applied Psychology Corporation for aid in preparation of various phases of this report, especially Dr. Alan M. Peabody.

ABSTRACT

A review of the literature revealed little specific to the subject, but did indicate that there exists a large amount of magazine and newspaper material reporting innovations devised by blind individuals and their employers for overcoming job difficulties, which should have many uses if collected.

Of the 178 plants surveyed by questionnaire, 68 replied, 28 reporting employment of the blind. Five of these firms indicated modifications in design of machines or workplaces primarily to accommodate the blind. Personal visits to five representative companies showed both need for and feasibility of human engineering. There is evidence that a systematic program of human factors engineering will yield beneficial results to the employer as well as to the blind worker.

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SECTION I: INTRODUCTION AND BACKGROUND

HUMAN ENGINEERING THE WORKPLACE OF THE BLIND IN INDUSTRY

Purpose of the Study

Objectives

This project, originally entitled "Human Engineering the Workplace of the Blind," was conceived as a small-scale or pilot study, with these principal aims:

(1) to ascertain the extent to which industries and businesses employing the blind have human engineered workplaces,

(2) to define ways in which human engineering might make employment of the blind practical.

Limits of Study

After some preliminary work, the decision was made to limit the scope of the project in two ways. The first decision concerned the proposed review of literature. This it was felt wise to confine to the United States alone. An initial investigation of the reports on jobs performed by the blind in other countries indicated that a complete survey could be time-consuming and might yield information of relatively little pertinence to the industries here. Such a limitation has undoubtedly meant the exclusion of some excellent material, particularly from Canada, England, and the Scandinavian countries. However, coverage of this literature might well be the sole aim of some future investigation.

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Secondly, it was decided to restrict the study of human engineering in the work of the blind to those jobs falling within a factory or industrial classification, thus eliminating consideration of business and office positions. It was found that much has been done in adapting office machines and routines to the needs of blind employees, with the result that this area alone is worthy of separate study, as well as being too large to fall within the scope of the current project. Consequently, the study of the operations and machines involved in typing, dictaphone, secretarial, and stenographic work, was not undertaken.

Human Engineering

Definition

At this point it may be well to define the field of human engineering and to show its relationship to the jobs held by the blind worker in industry. Also called human factors research, man-machine research, or engineering psychology, the field of human engineering is a union of psychology and engineering. It has been defined as "the science of designing machines to be operated by people," or, more simply, fitting the machine to the worker.

Because the man-machine system consists of man and machine working together to attain a common goal, the degree of success attained will depend upon how accurately the designer matches the

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demands of the machine to the capabilities and limitations of the man. Human engineering specialists are trained to match men and machines for optimum efficiency. Such tailoring of equipment to fit the psychological and physiological capabilities of the individual allows an operator to do his work quickly, accurately, and with less effort and confusion. Also, well-designed equipment leads to reduction in training time and cost.

Psychology possesses much information concerning the sensory and motor capacities of human beings. The experimental data includes such information as response time under various conditions, factors minimizing learning time, optimum control arrangement for equipment operation, and knowledge of the ways in which such other critical factors as vision (or lack of it,) hearing, and smell can influence an operator's ability to do his job.

In addition to the various branches of engineering and psychology, human engineering draws upon such related disciplines as sociology, physiology and anthropology. Medicine, mathematics and physics also make significant contributions to this new specialty.

In the design of our modern complex equipment too often little systematic consideration has been given to the capabilities and limitations of the average person and how he might be able to perform a task or operate and maintain equipment. Designers have considered the machine the constant factor, and thought of the human operator

as a variable which could adjust to the conditions presented by the machine. In human factors engineering it is recognized that the ability of the worker to adjust to the machine, and simultaneously do useful work, is limited. That is, the more demands placed on a worker's adjustment capacities, the less work he is able to perform. Careful consideration is given the warning and indicator systems of machines so that they require the least possible conscious effort on the part of the operator and therefore detract as little as possible from his performance. In short, the human engineer strives to design machines which are compatible with man's capabilities and limitations and which take advantage of his previously learned subconscious patterns of behavior.

Background

The growth of human engineering was extremely rapid during World War II. New machines and instruments were developed which did not function in the field with the efficiency which had been shown during engineering and laboratory tests. When it was found that such machines exceeded the natural capabilities of prospective users, psychologists were asked to make recommendations for the redesign of equipment which would not overtax the sensory and motor capacities of the operators. By the end of World War II a number of people were engaged in what had come to be known as human engineering.

Because until recently much military work was classified, industry has been slow to learn of, and thus to avail itself of the

military human factors engineering advances. There is little doubt that increased emphasis will follow, now that the practicality of its techniques has been demonstrated.

Research Plan

Research done on the project was divided into three separate phases, each of which will later be described in detail:

(1) review of the literature;

(2) survey by questionnaire of industrial concerns, regarding number of blind employed and kind of work done by them;

(3) visits to plants employing the blind, to observe them at work and view human engineering adaptation.

SECTION II: BLINDNESS

Definition of Blindness

Concept Held by Public

Blindness seems a simple enough concept to grasp; but it is in actuality not a simple phenomenon. To the general public the term blindness often means a complete absence of vision. Yet the amount of vision possessed by blind people actually varies greatly from person to person, just as the legal definitions of blindness vary from state to state.

Moreland (1943) points out that during years past, there has been a trend for workers among the blind to include a larger and larger percentage of the visually handicapped, which is in direct conflict with the general public's conception of blindness, i.e., complete absence of the sense of sight.

Thus in actual practice the term may denote loss of sight ranging from total inability to distinguish light from darkness, to a visual defect preventing the successful pursuit of certain activities for which vision is needed.

The lay public would probably be surprised to learn that, of the more than 300,000 legally blind in the United States, 60 per cent have a little sight. This ability to see, however, ranges all the way from light perception (what the normal eye has with lids closed), to light projection (detection of large objects), including recognition of hand movements and counting fingers at one foot or more, and the reading of the Snellen 200-foot character by the corrected better eye at various distances up to 20 feet.

Generally Accepted Definition

The generally accepted definition, according to the "bible" in the field of work with the blind (Zahl, 1950) is as follows:

"a visual acuity of 20/200 or less in the better eye with proper correction, (according to the Snellen eye chart of measurements), or limitation in the field of vision such that the widest diameter of the visual field subtends an angular distance no greater than twenty degrees." This is the definition most frequently used in the United States by federal and state governments, and is the one used for the present study.

Ritter (Ques. and Ans. on Low Vision - 1957) has given a very lucid explanation of this definition, as follows: "A person is termed blind when, wearing proper corrective glasses, he is able to see no more at a distance of 20 feet with the better eye than the normal eye can see at 200 feet, or if his field of vision, regardless of central sight, is no greater than 20 degrees. Since visual acuity is usually expressed in terms of eye chart performance, normal sight is thus 20/20, and the sight of a person who is just inside the definition of blindness is 20/200. Many people have no more than 20/200 vision without glasses, but see normally when glasses are worn. Such persons, obviously, are not considered blind. It is only when corrective lenses improve the sight to no more than 20/200 that the person is said to be blind."

Although the legal definition of blindness is generally accepted as meaning 20/200 vision, the Federal government has defined as "industrially blind" those with a visual handicap of 20/120 in the better eye or less.

Classification of Blindness

Lebensohn (1956) gives the following classification for impaired vision:

(a) Social blindness--vision below 4/200. Those so afflicted cannot travel without some aid.

(b) Partially seeing - corrected acuity below 20/70. Here he gives as an example the child who cannot progress well in the regular classroom without special help.

(c) Occupational, economic, or legal blindness - vision corrected to 20/200 or less in the better eye.

The third classification is also often defined in general terms as the absence of ability to do any kind of work, industrial or otherwise, for which sight is essential.

Number of Blind in United States

Few Statistics Available

It is of interest that there are no reliable accurate statistics concerning the number of blind persons in this country. However, best estimates by workers in this field place the number at about 320,000. Of this number, approximately 55% are male and 45% female. 52% are over 65 years of age, and 10% are less than 20 years old. 79% are over 40 (Switzer, 1957).

Importance of Reliable Statistics

Hurlin (1953), author of Estimated Prevalence of Blindness in the United States, points out that even though reliable statistics have long been generally lacking, such information, accurately compiled, is vitally important for use in evaluating the results of measures taken to control blindness, and in planning and administering programs of both service and assistance for the blind.

Census Enumerations

The last official census of the group was made in 1930. In 1940, for the first time in a hundred years, the United States Census Bureau made no attempt at a general enumeration of the blind. Nor was a census taken in 1950.

In the 1920 and 1930 census reports, the Bureau lists some of the difficulties involved in making a count: (Fifteenth census of the U.S., 1931)

"(1) It is very hard to formulate an adequate definition of the group to be considered.

(2) Even with a careful definition, a large element of personal judgment enters into the decision of an enumerator as to whether a given individual should be reported as blind.

(3) Inconsistencies result from the varying intelligence and persistence of the enumerators.

(4) There is often reluctance on the part of the blind persons or their relatives to admit blindness. This attitude is emphasized in the case of children."

In addition, since the accepted definition of blindness per se today depends upon tests which require special equipment and can be administered by trained personnel only, it may be safely assumed that a relatively small percentage of the total population has been so examined. Thus it is easy to see why the job of enumerating the

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blind has been a very difficult one; to see why, also, it is not possible to state with any degree of accuracy how many individuals fall within the definition of blindness. Hence it becomes necessary to depend upon estimates for a picture of the blind population of the United States.

Increase in Estimates of Number of Blind

In the 27 years since the last official census in 1930, authorities in the field have upped the estimated number of blind in the country until at present, according to some, there are nearly five times as many as the last census figures showed. Even the best estimates probably include omly those persons who are blind within the definition of economic blindness and who recognize an effective handicap.

Many persons whose deficient vision, if tested, would be recorded at the upper limit of the definition for blindness do not regard themselves as blind, with such marginal defects, and hence do not tend to volunteer in any registration procedures or contact such agencies as are engaged in working for the welfare of the blind.

SECTION III: LITERATURE REVIEW

Review of the Literature

Veterans Administration Study

Although a review of the literature on the subject of the blind proved to be extremely enlightening (and time-consuming), little material was found which dealt directly with human engineering in the work of the blind employee in industry.

An American Foundation for the Blind publication "Current Research in Work for the Blind" (Raskin, 1953) shows the majority of research studies to be in the area of personal adjustment and psychological development. Only one project, a general follow-up study of blinded veterans of World War II and the Korean War, sponsored by the Veterans Administration, deals with the employment of the blind, and then in a more or less incidental fashion: the social workers conducting the study questioned approximately 2000 non-hospitalized blinded veterans in structured interviews which included an item requesting a description of present occupational situation, work adjustment, and previous vocational experience. A separate report on this portion of the whole study was published in a pamphlet entitled "Occupations of totally blinded veterans of World War II and Korea." (U.S. Dept. of Veterans Benefits, 1956)

The report described in some detail the vocational status and adjustment of 388 of the veterans interviewed. Only totally

blind men were included, on the premise that "knowledge of the kinds of work that can be done by persons who have partial vision is likely to have limited utility for people who have no useful vision."

Information covered includes nature and level of the veterans' previous employment, kind of assistance or training received in securing present employment, job satisfactions, special working arrangements, and prospects for continued employment.

Primary value of the study, as the authors state, is in the listing of a "large and unprecedented variety" of occupations in which totally blinded veterans are successfully employed. Thus there is opened up to the blind many new occupational possibilities, particularly since some veterans are also reported as successfully employed in fields of work heretofore generally regarded as requiring vision.

In spite of the fact that many veterans were reported as doing unskilled or semiskilled work, the general overall level of employment appeared to be considerably higher than for the years before the war.

Jobs held by the 388 veterans surveyed were given Dictionary of Occupational Titles (Part IV) classifications. Six major occupational groupings emerge, as follows: professional, technical, and managerial work, 147 veterans employed; clerical and sales work, 54;

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service work, 6; farming, 48; mechanical work, 37; manual work, 96. Vending stand operation was classified approximately as a managerial occupation and the survey showed that it provided employment for more blinded veterans (55) than any other classification.

As might be expected, employment in a number of important fields was not represented, primarily because of visual requirements.

Of the blind veterans reported employed in factories, the group with which we are most concerned here, 37 workers fall within the category for mechanical work, and 96 in that of manual work. No complex machine operating or equipment tending was reported. Only observational work reported was simple sensory inspecting (non-visual). A heavy concentration (45) was noted in benchwork (assembling and related) and in manipulative machine operating (24).

It may be enlightening to list from the report those adaptations which might reward further investigation on the part of the human engineer, since they might well promote efficiency, not only for the work of the blind, but also for the sighted. (An elaborate code system used by the Veterans Administration to protect the individuals included in the study made it impractical for the author of this study to obtain further information.)

Doctor of chiropractic - takes X-ray pictures with special equipment he has developed. (Had been told by X-ray companies that

they could find no way for a blind person to take X-rays).

Telephone Operator II - Fire-alarm operator....Required a changeover in alarm system from lights to buzzers.

Proprietor, hardware store - Has special screen rack for sizing, measuring, and cutting screens of any desired dimensions. Uses Braille ruler with special pipe threading machine to cut any desired threads. Uses special stapler to insert geiger points.

Lens Grinder, Bench - Grinds lenses for camera and gunsights. All equipment same as for sighted workers except two gauges, the thickness gauge and spherometer, which veteran has fixed with Braille type and numerals. This was his own idea, and after demonstrating at own expense with one gauge, the second gauge was made for him.

General Repairman - Uses a few special devices and some unique methods which he has devised for himself.

Radio mechanic, aircraft installation - uses special electronic test equipment adapted for blind from conventional equipment.

Cabinetmaker - Special arrangements enabling veteran to operate the machines were developed by his independent instructor, including safety devices and Braille measuring devices.

X-ray developer, employed in hospital - veteran identifies films for doctors by own system of identification.

Inspector - Gauges outside diameter of the outer race of roller bearing for final size. This is done with the aid of

special electronic sounding equipment developed by the company and applied to a standard gauge.

Operates drill press - wide variety of drilling operations. Foreman has devised many special jigs and dies to make veterans' performance possible.

Operates pulpwood shredding machine - operates machine by manual switches. Lights have been replaced by horns to signal off and on control instructions.

Lollar Smith Study

An older study, done by Lollar F. Smith (1945) at the Mines Equipment Company in St. Louis, Missouri, titled "The Adjustment of the Blind to Industrial Employment," studied 18 blind workers employed on eight different types of jobs (including over 150 operations) during a 15-month period of employment. Workers were employed in inspection jobs, where go no-go gauges were used, on machine jobs operating mold and drill presses, on tapping machines, and in bench assembly of small parts. Blind employees also worked in the packing department, stock room, and on maintenance and repair of equipment used on the assembly line. Instruction was given individually by the supervisor to each new blind employee, and was reported to require no more time than for beginning sighted employees.

Smith found, from verbal reports made by blind workers (corroborated by their supervisors), and from study of time-motion

plant records, that performance, quality, speed and output of the blind were as good as, and sometimes superior to the sighted workers'. In addition, no blind worker suffered an accident during the 15-month period of the study.

An attempt was made by the writer to contact Mines Equipment Company to see if blind workers are still employed there today. Tracing of the company through various industrial lists showed the name to have been changed, and no answer to the questionnaire sent to the new company was ever received.

McFarland Comparison of Sighted and Blind Workers

Of the few remaining studies made of the blind worker in industry, one of the most recent and comprehensive is that done by McFarland, the results of which were published in 1956. A comparison was made of the work efficiency of blind and sighted individuals employed at similar jobs in industry. Thirty-eight subjects from each category were distributed by pairs in 33 companies located in five eastern seaboard states (Connecticut, Maryland, New Jersey, New York and Pennsylvania.)

The criteria of efficiency used were annual earnings, production (quality and quantity), attendance (absenteeism and tardiness), and safety records. The subjects were involved in a large variety of jobs, including several types of machine operation, packing, and assembly work. Tests of intelligence, finger

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dexterity, and hand coordination were given for their possible predictive value. A questionnaire was also used.

A statistical summary of data compiled showed no significant difference for annual earnings, production level, and absenteeism. The blind workers did, however, have significantly less tardiness than the control group. Conceivably, the greater motivation and stability of the blind worker offsets, productionwise, his impaired ability.

Of the analytical comparisons made of the subgroups of the criteria, the Pennsylvania Bi-Manual work sample assembly and disassembly, administered as part of the motor skills tests, showed some significant "t" differences. The confidence level was not reported, and McFarland suggests that this skill may not be a critical one in some jobs.

McFarland concluded that the results of his study justified the statement that blind workers are at least as good (efficient) as their sighted companions.

Performance Study on Complex Machines at Abilities Inc.

A two-year study to ascertain how effectively severely disabled workers may operate complex modern machinery is being conducted by the Human Resources Corporation on Long Island, research affiliate of Abilities Inc.

Organized in 1952 by Henry Viscardi and Arthur Nirenberg, both disabled, Abilities Inc. employs only handicapped persons. An

industrial firm, the company engages primarily in sub-contract work for manufacturers of electrical and defense equipment, many of them in the field of aviation.

An assessment of the efforts, problems and accomplishments of 300 of the firm's disabled employees who are engaged in the operation of new and complex industrial machines is being made by a staff of specialists in industrial medicine, personnel, psychology, safety, labor and rehabilitation. A few blind workers are among those participating in the study. The grant, made by the Office of Vocational Rehabilitation, will end in 1958.

Results of this research project, with its examination of the kinds of performance sustained by handicapped employees working both with and without adaptation of machinery and equipment, may well provide further information on the value of "human engineering the workplace of the blind in industry."

Lende Bibliography

Perhaps the most complete coverages of material pertaining to the blind industrial worker exists in Helga Lende's "Books about the blind: a bibliographical guide to literature relating to the blind," published in a revised edition in 1953 by the American Foundation for the Blind. The volume contains a four-page section "Blind in industry", with a total of fifty-four annotated references listed. Although none are directly pertinent to the topic of human

engineering in the workplace of the blind industrial employee, many contain related material from such areas as employer and employee reactions to the blind, job performance, etc.

Recommendation for Survey of Ephemeral Material

In conclusion there is no doubt that an enormous literature exists on the subject of the blind, but much of it, as Helga Lende notes in the preface to her Books about the Blind (1940), "may be said to be repetitious and in many cases...of a more emotional than factual character." In general too, a survey of the material on the blind points up the fact that this population is one which has been studied or written about mainly on an individual or case basis.

Because of this peculiarity the authors wish to recommend a more comprehensive and thorough survey of the existing newspaper and magazine material which has been devoted to blind individuals and their activities, than was possible to make during the course of this research.

The literature survey completed for this project gave evidence that there is a large amount of ephemeral material reporting innovations devised by blind individuals who have overcome difficulties confronting them on their jobs.

The collection of that portion of this material which deals with positions in industry might be extremely worthwhile, both as an aid in furthering future employment of the blind, and illustrating applications of human engineering which have been made to jobs held by them in industry.

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SECTION IV: EMPLOYMENT OF THE BLIND

General Problems in Obtaining Employment

Factors Other than Vision Involved

Although the routine of daily living no doubt presents the greatest single difficulty for a blind person, the problem of employment is perhaps next most severe. Some authorities (League of Nations Report, 1928) have estimated that the loss of vision impairs an individual's earning capacity in amounts varying from 50 to 60 per cent. However, other factors such as ability and initiative, education and experience, and the general employment situation, certainly are important also.

These are, of course, factors which can affect the sighted too. Such problems as age, employment record, other physical disabilities, and personality idiosyncrasies affect employability of both the blind and sighted. In addition, blind people must of necessity (except in the sheltered workshop) compete with the seeing individual for every job obtained and held. Thus it may be seen that for an otherwise employable person, blindness may well be only one of many factors operating in the determination of his eligibility for any specific position.

Like any employable group, the blind are affected by economic conditions. Even during periods of high employment, some employable blind individuals are without work; during periods of great unemploy-

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ment, much larger numbers of employable blind find themselves idle. So the problem of the blind person wanting work, but unable to find it, is a part, not so much of the problem of blindness, as of the larger problem of supply and demand.

History of Industrial Employment

Institutional Employment

Throughout the history of work for the blind, the sheltered workshop has been the principal source for jobs held by the blind. Partly as a result of this situation, the lay public has come to associate the vocational skills of the blind with the limited number of jobs available in institutions for the blind, e.g., weaving, chair-caning, piano tuning, broom making, etc. Unfortunately, this concept has also been held by some professional placement workers for the blind.

Employment during Two World Wars

The first World War helped to increase the number of blind employed in industry, but a majority lost these jobs in the 1921 recession.

The manpower shortage during World War II, together with the establishment of the vocational rehabilitation program for the blind, resulted in the placement of greater numbers of blind workers in industrial jobs than ever before. Estimates place the number of blind men and women thus employed at approximately 5,000.

As a result of the war, enough blind were placed to prove that they could perform as well as or better than the average factory worker. It was also shown that blind persons could participate in a far wider variety of occupations than had before been thought.

In the years following World War II new areas of employment for the blind continued to develop. A prosperous economy, and the growth of new industries such as plastics and electronics were factors partially responsible for the expanded opportunities for blind workers. Much credit for the increased employment was due also to the placement officers working with the blind. The policy of carefully selected jobs plus carefully trained workers resulted in consistently good performance on the part of blind employees. Hence employers in all areas and in all states hired increasingly larger numbers of the blind.

Today roughly 18,000 blind persons are employed in the United States, approximately 6,000 of these working in the manufacturing industries. In addition, the largest number of blind now receiving vocational training are those being trained in some industrial skill.

Problems in Obtaining Employment in Industry

Objections Held by Employers

To get general acceptance of blind individuals as potential employees, placement counselors for the blind should insist that

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employers hire strictly on the basis of the individual's ability to do the job. Clunk (Donahue and Dabelstein, eds., 1950) has listed 57 objections made by prospective employers to the employment of the blind. Since many of those cited do not apply to jobs held in industry, and since there exist several detailed discussions of these points in the available literature on the blind, no attempt will be made here to examine them. However, those objections to the hiring of the blind which are most frequently made by employers seem to fall into several broad categories. These are presented below, together with the appropriate counter arguments (after Chappel, 1953):

1. "A blind person can't do the job.

Examples can be cited for blind personnel engaged in exact job in similar industry.

Blind placement specialist may visit factory to demonstrate that he can perform the operation in question.

Placement specialist may suggest substitution of device, (at no expense to employer), or modification or change in work area, (which may also increase efficiency of sighted workers on same job).

2. "A blind person working in the plant may be injured."

The 4-Point Pattern of Safety developed by the Office of Vocational Rehabilitation (McAuley, 1954) and used in training of blind for industrial jobs, may be explained and demonstrated.

Casualty insurance companies' statements which show equal or better safety records for blind persons than for sighted workers on similar jobs may be exhibited.

3. "I don't want a guide dog in the factory."

It may be pointed out that not all blind employees use guide dogs and that a worker can be placed in his shop who does not use a guide dog.

Employer may also be told that a guide dog is well-trained and is not a pet. It will not expect or demand attention.

If desired, the dog may be muzzled for a time.

Liability insurance can be carried on the dog.

4. "Putting a blind person on the job will place an extra burden on the supervisor."

An offer may be made of help from the placement specialist during the orientation process.

5. "Previous experience with a blind employee was unfavorable."

Placement specialists can find out what the experience was, and point out that it is the individual, not the group, who should be judged.

6. "Our work is seasonal. I wouldn't want to lay off a blind person."

It can be pointed out that blind people do not want special consideration; that they want to be treated like other

wage-earners.

7. "There will be objections from the union."

It can be shown that so far all the unions admit blind persons to as high a rating as their skill, training, and ability permit.

The problem of obtaining tools and supplies for the blind factory worker is also one frequently mentioned by prospective employers. However, there are several ways to overcome this difficulty. Depending upon location, the blind person can be taught the route to the supply center, can travel there with a sighted person when he is making the trip anyway, or can be placed so that he works next to a sighted worker, who can pick up extra parts for the blind employee when he goes for his own.

Operation of Power Tools and Equipment

Chappel, an expert on the capacities and capabilities of the blind industrial employee, who is blind himself, and who has successfully performed all of the operations for which he recommends blind employees, remarks (Chappel, 1951) that custom has caused society to believe sight an essential factor for the operation of most power equipment, as well as for the manipulation of hand tools; this in spite of the fact that experience has shown that persons, without vision, when properly selected and trained, are capable of

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operating most power equipment and performing most machine operations.

Training

McAulay (1954), writing on training of the blind, concurs with Chappel's views, but cautions:

"In teaching the principles of economy of time, motion, and energy, to a blind worker, more time is required than for sighted students. The blind person should be taught to establish the pattern and follow it for every action component involved in the operation of any machine tool or any bench job. For example, in operating a machine tool, the chuck wrench should be laid down in a certain position and location, so that it will be most convenient to relocate, and so that it can be picked up again without having to be turned around in the operator's hand."

He cites as an example the procedure to be used for a bench job:

"Carefully laying down a file or scale in such a way that it does not complicate the picking up of the succeeding tool, and in such a way that it will be easy to pick up again, and apply to the work, without changing hands or making any extra motions."

Advantage of Employing Blind Industrial Workers

Although it is oftentimes difficult to convince prospective employers that this is so, it is nonetheless true that certain

advantages may accompany the employment of a capable blind worker. Because of his visual limitations, the well-trained blind employee possessing initiative and judgment can and often does bring to his work job organization which may result in saving of time, effect greater economy of movement and effort, and achieve a higher rate of production.

Because they are apt to be cautious about accidents, most blind employees tend to give close attention and strict compliance to safety rules and regulations. In addition, in many factories the record of absenteeism, tardiness, and labor turnover for the blind is often superior to that of the sighted worker.

Conditions Limiting Employability of Blind Industrial Workers

Transportation

Many of the limitations upon the employment of the blind industrial worker can be successfully overcome. In this section, however, it is our purpose to list some of the limitations inherent in blindness which may have to be faced by the blind employee hoping to secure an industrial job. First, perhaps, is the matter of transportation. Depending upon location, amount of traffic, and kinds of transportation available, or a combination of all these factors, it is true that for some blind workers some jobs available in some plants cannot be considered, because of limited travel ability.

Work Environment

Second, unsuitable plant facilities, such as unguarded machinery, narrow passageways, moving platforms, and supplies which are not always placed in the same position on the floor, may make some plants which have openings in jobs requiring travel within the plant prohibitive. (Clunk, 1938).

Clunk (1938) has defined four other limitations to jobs which may be held by the blind in industry, as follows: The size of article(s) to be handled by the blind employee must be of medium size, and within arm's reach; a blind employee should not be placed on a job where (1) control of the machine being operated is not with the worker; (2) the job involves use of adhesive materials, printed matter, gloves, or tongs, and (3) large or sharp metal shavings will be cut by the machine being used.

Two additional factors which limit the jobs open to a blind worker were listed by the New York State Department of Labor in 1956 as follows:

1. Work preferably should be limited to one area, rather than necessitating moving from one area to another;

2. Materials used in the operation for which the blind employee is hired preferably should be pre-positioned.

Jobs involving the use of visual dials or guides, or requiring the reading of clocks, gauges, and distinguishing colors,

are generally regarded by employers as impossibilities for the blind. However, tonal devices may often be substituted for the visual dials and guides, and Braille instruments or tags supplied in place of clocks, gauges, or distinguishing colors. Such changes may be made at nominal expense to the firm, or with the cost of the adjustments being paid by the agency placing the blind worker.

Working near or with moving parts is considered too dangerous for blind people in most plants. Yet there are instances of these jobs being handled by workers without sight who use air currents or vibrations to aid them in safe procedures. Other blind employees on similar jobs depend upon rigid training procedures in placement of body, hands, feet, and materials to perform their jobs safely.

Chappel (1953) has suggested that many problems, such as those involved in travel within the plant, pre-positioning of materials, etc., may be solved by the blind employee working as part of a team, or being placed next to a sighted worker. He also urges greater use of substitute devices wherever necessary.

Lack of Flexibility

A criticism sometimes made of blind employees is that they are not versatile. Employers occasionally complain that blind workers are usually very well-trained for a specific job, but are often found incapable of converting to other work because of lack of preparation. It was the author's observation, however, that blind employees engaged in a large eastern furniture factory could hold as

many different jobs within their department as any of the sighted workers, and with no more orientation. One authority has suggested that the entire rehabilitation process be re-examined to explore the possibility of preparing the blind for more than one job, and has added the thought that almost all workers in our rapidly changing economy would benefit from training in more than one job--a premise difficult to dispute.

Philosophy of Placement

Who Makes the Necessary Adjustments?

By definition the blind worker is different from the sighted worker, and it is almost axiomatic that this difference will be the basis of some difficulties for both the worker and his employer. There are three possible methods of resolving these difficulties: the employer makes all of the adjustments and concessions to the worker's handicap, the employee is so completely adjusted that he can assume the responsibilities of the job with no changes on the part of the employer, and both parties make reasonable adjustments.

The first solution is obviously impossible from a psychological and economic standpoint. We may therefore dismiss it from further consideration.

Problems of the Placement Officer

The placement official attempting to convince a prospective employer that the blind worker will cause him no inconvenience and will necessitate no changes at all is sure to encounter difficulty,

since often this assurance can not honestly be given. Thus, placement official has a second choice; he can inform the prospective employer of the possible problems, and perhaps lessen the probability of placing the worker.

The New York State Department of Labor in 1956 listed the following six items as suggested minimum standards of employability for the blind:

"To be 'employable', a blind person must be able to:

1. Work at least eight hours a day, five days a week;
2. Travel independently;
3. Compete in job performance on equal terms with the sighted;
4. Make the proper social adjustments required in working with others;
5. Resist asking for special privileges, no matter how slight. Anything, beyond superior performance and good behavior, that sets a blind person apart, is out of order;
6. Meet the standards of a carefully selected job; any deviation making the blind person conspicuous must be avoided."

The philosophy underlying these standards is that the blind worker is likely to encounter some problems and must not

ask for concessions in solving them. This viewpoint removes responsibility for adjustment from the employer and aids the placement official, if not the worker.

New School of Thought

As a matter of fact, many workers today are concluding that there is no reason for hesitation on the part of the blind in admitting the need for certain adaptations. Management continually deals with employees who require specialized environment or conditions; such employees make no apologies; their employers expect none. The short man, the hard-of-hearing worker, the obese employee, the woman who has severe varicose veins, the minority who observe different religious holidays, all are in a category no different from that of the blind worker who must bring a guide dog to work with him. So long as employers deal with people as well as machines, concessions will have to be made, and the blind worker, in comparison with his sighted fellow-workers, should thus seem neither the exception nor an oddity.

A further, and perhaps more important reason for a frank admission to the employer that hiring a blind worker may involve some difficulties and some adjustments in the environment where the blind person will operate, is that in the majority of cases the innovations or adaptations made will also prove to be of value to the sighted employees working in that environment, either in

[illegible]

SECTION V: SURVEY BY QUESTIONNAIRE

Questionnaire Mailing

Selection of Firms for Mailing

The second phase of the study consisted of the construction and mailing of a questionnaire to 178 industries engaged in a wide variety of manufacturing pursuits. Three hospitals and eleven military installations known to have employed the blind were also included. (See Appendix A for a complete list of the firms which were contacted.) The most difficult part of this questionnaire phase of the study lay in the acquisition of a mailing list.

A list of firms employing the blind might have been compiled from a painstaking perusal of the existing ephemeral literature: (see discussion of such material on page 20). The amount of time which this approach would have required did not make it a feasible one.

However, a list of industries employing the blind was found in two titles published by the National Society for the Blind in 1943. The first report was called "Blind Persons Employed in War Industries in the United States as of January 1943." The second, edited by Lawrence Q. Lewis, is titled "Blind Workers in United States Industries; Photographs and Letters from Their Employers." Names of the companies given are generally the same in both publications, with the first, which lists industries by state, containing the larger number.

It was decided to compile a partial mailing list from these reports, on the premise that a percentage of the firms listed might still be employers of blind personnel today. Investigation, aided by several industrial directories, disclosed that many companies had changed addresses, gone out of business, acquired different names,

engaged in the manufacture of new or additional products, or merged with other organizations. However, in spite of such difficulties, it was found possible to use a total of 37 of these companies for questionnaire mailing.

At the same time that the preliminary mailing was made to the 37 firms taken from the two lists referred to above, a mailing was made to a total of 54 firms which had been selected at random from the following industrial directories: MacRae's Blue Book Directory of American Industry, Moody's Industrial Manual, Poor's Register of Directors and Executives, Thomas Register of American Manufacturers and the National Academy of Sciences' Industrial Research Laboratories of the United States.

"Random" selection from these sources of the 54 companies was influenced by two considerations: size, and geographical location. In general, firms employing several hundred or thousands of people were chosen, since it seemed logical that at least a few blind employees might be found among any large number of workers. (However, results later proved such an assumption to be unfounded.)

The second criterion of selection, geographical location, was applied to all questionnaires mailed, and will be discussed in detail later.

In the meantime, inquiries for names of industries employing blind personnel, or information as to where such names might be obtained, had been made from such organizations as: Division for the Blind, Office of Vocational Rehabilitation, Health, Education and Welfare; Veterans Benefits Center, Veterans Administration; United

States Employment Service; American Foundation for the Blind, and several others.

Exploratory letters were also written to the State Commissions for the Blind in the states of Maryland, New Jersey, and Delaware. A total of eight company names were obtained from the three Commissions.

A visit to the Blinded Veterans Association, 3408 Wisconsin Avenue, N.W., Washington, D.C., yielded excellent results. Through the courtesy of Mr. Irving Schloss, Director, and Dr. R. Thompson, Blinded Veterans Association files were made available to the writers, and 87 names of firms who employ blind workers were thus obtained.

Geographical location

A perusal of the various lists of firms used, made at the time each was compiled from the three sources previously described (1. National Society for the Blind reports; 2. industrial directories; and 3. Blinded Veterans Association files), revealed a widespread geographical distribution throughout the entire United States. In order to most wisely use the sum allotted for travel in the research grant, it was decided to mail the greatest concentration of questionnaires to eastern states. Accordingly, of the total number of 178 questionnaires which were eventually sent out, 110 went to firms located in Connecticut, Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania and Virginia.

In addition, some firms found in the three sources used were included in the questionnaire mailing because of the possibility that staff members traveling on other assignments might be in or near the cities concerned.

In spite of the above considerations, firms located in states ranging as far north as Minnesota, west as California, and south as Georgia, were contacted.

Officials addressed

Insofar as possible, all questionnaires were addressed and mailed directly to the president of the firm being contacted, or the personnel director, or equivalent. Names for both officers were obtained from the industrial directories referred to earlier. It was felt that this procedure would result in responsibility for return of the questionnaire being directly assumed, or if the responsibility were delegated, would carry with it a stamp of authority. With a questionnaire less difficult to complete, such a step would no doubt be unnecessary. That it brought good results in this particular instance is attested by the fact that a total of 25 personal letters were received by the author from the various firms contacted. The title or position of those answering by personal letter and the number in each category are listed in Table 1.

Materials Accompanying Questionnaire

Copy of the items mailed to the various industries will be found in the Appendix. (See Appendix B). In addition to the

Table 1

Positions of Those Answering

Questionnaire with Personal Letter

Title or Position in Firm		No. in Each Category
President of firm		2
Personnel Director or Manager (or equivalent)		7
General Manager or Director		2
Manager Employee Relations, Manager Placement & Employee Relations, Placement Manager		9
Research Statistician		1
Administrative Manager		1
Vice President or President of Industrial or Public Relations		2
Vice President of Manufacturing		1
	Total	25

questionnaire proper it included a covering letter, a one-page explanation of the application of human engineering to the work of the blind, and a reprint on the subject of human engineering in general.

Covering letter. The covering letter consisted of a mimeographed form letter, with the date, name and address typed in for each firm. Signature was original. Information covered in the letter pertained to source of support for study, statement of purpose, and a request to note the proper item on the questionnaire if the firm were interested in receiving the finished report.

Note about human engineering. The single page following the letter gave a brief paragraph description of the work of the human engineer, together with four examples of ways in which changes can be made to aid the blind employee in industrial situations.

Reprint. The enclosure of the reprint on human engineering (written by the recipient of this grant, and originally published in the February 1956 issue of the technical journal "Research and Engineering") was an attempt to furnish further information for those receiving the questionnaire who did not feel they had obtained a clear enough grasp of human engineering from the single-page "Note", or who wished answers to questions

arising on the subject.

Since human engineering is one of the newest branches of a comparatively new field (applied psychology) and is relatively unknown to many industrial people, it was felt that the two enclosures explaining it were warranted.

Questionnaire Construction

Determination of questionnaire content. At the outset, it was obvious that grant funds would be too limited to allow visits to all the factories which might respond with information indicating existence of human engineering adaptations. Hence it was decided to attempt to obtain by questionnaire as full a written description of each adaptation as possible. There were two reasons for this decision: (1) the information would be necessary to aid in judging what factories would be most worth a personal visit in terms of accomplishing the objectives of the study; and (2) for those plants not visited, the information on the questionnaire, if adequate in detail, would provide records valuable for this and future studies.

Description. The actual questionnaire was comprised of five pages, containing five multi-part questions. Preliminary information requested on page 1 included name and address of firm, name and position of person completing questionnaire, and space to indicate whether or not the company wished to receive a

final report of the study. Question 5 asked for permission to visit the firm, and with whom arrangements for a visit should be made.

Question 1 requested the respondent to circle the number of blind workers employed (as high as 50), and to list other firms (if known) which employed blind people.

At this point, those respondents who had indicated that no blind were employed in their plant were asked to return the form, with any comments they might have.

Question 2 occupied all of the next sheet and half of page 3. It asked for the kind of machine operated by blind personnel and the number employed on each type. Names of items assembled, inspected, sorted, or otherwise handled (packing, wrapping, crating) and the number of blind engaged in each operation were to be listed next. Another part to this question on page 4, requested description in a few words of other jobs in which blind workers might be engaged within the plant.

Questions 3 and 4 were the two items requiring essay-type answers, and the most difficult to do. They asked for brief descriptions of changes or innovations made in the blind workers' equipment or environment in order to increase efficiency and ease of performance, and what (question 4) in the respondent's opinion, was the most outstanding or significant adaptation made by the blind personnel or their supervisors.

Results

In Table 2 will be seen the results for the complete mailing of 178 questionnaires. A return of 38 per cent, or a total of 68 answers were received, 37 from companies which employed no blind, and 28 from firms which carried blind workers on their payrolls. The total number of blind employees reported for the 28 firms was 121, with Timken Roller Bearing Company employing the largest number, 20, and six companies reporting one blind employee apiece.

Three other firms wrote in answer to receipt of the questionnaire, but did not give the requested data. One company asked for further information. Although this was supplied, their questionnaire was not received. Another firm said it did not wish to participate in the survey, and a third wrote promising cooperation, but did not return the questionnaire.

Table 3 gives a breakdown of the results shown in Table 2, with returns given for each of the three separate mailings. The first mailing of 37, made from the National Society for the Blind reports, yielded 32 per cent return, or a total of 12 questionnaires received.

Of the 54 questionnaires mailed out to firms selected at random from the various industrial directories, 23, or 43 per cent, were returned.

Table 2

Disposition of Questionnaires

	Number	Per Cent
Total number of questionnaires sent	178	
Total number of firms replying	68	38
Number of questionnaires answered by companies employing blind workers	28	16
by companies not employing blind workers	37	21
Number of firms replying but not sending requested information	3	1

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[illegible]

[illegible]

[illegible]

[illegible]

Table 3

Returns for Three Questionnaire Mailings

Number and Mailing	Number of Firms Returning	Per Cent Returned
37 questionnaires	12	32
(National Society for the Blind)	3 employed blind 9 did not	
54 questionnaires	23	43
(Industrial directories)	3 employed blind 20 did not	
87 questionnaires	33	37
(Blinded Veterans Association)	22 employed blind 11 did not	

NOTE: 3 firms replying but not giving requested information are included here as firms which did not employ blind.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
		[illegible]
	[illegible]	[illegible]
	[illegible]	[illegible]
	[illegible]	[illegible]

[illegible]

The 87 questionnaires which were sent to names obtained from the Blinded Veterans Association yielded a 37 per cent return, 33 questionnaires being mailed back.

Character of returns. Of the total of 68 replies received, 49 firms returned a completed questionnaire, and 19 answered by other means for one reason or another.

It is interesting to note that 27 of the 28 firms employing blind workers returned a completed questionnaire, only one answering by personal letter instead.

Of the 37 firms who answered by reporting that they did not have blind employees, 22 returned page 1 of the questionnaire, as instructed, 12 sent personal letters, and 3 wrote one line on the original material mailed them.

Four of the 37 firms replying negatively reported that they had at one time had blind employees, and two wrote that they have handicapped workers at present but no blind ones.

Distribution of workers. The 28 companies mentioned above employ a total of 121 blind workers. The range is from one to 20 workers per company. Most of the companies employ four or fewer blind workers. These data are given in Table 4.

Kinds of businesses hiring blind. Wide ranges of company size and product are represented in the sampling. The firms employing blind workers ranged in size from some with fewer than 50

Table 4

Number of Blind Workers Presently Employed by Firm

No. of Workers	No. of Companies		Total No. of Workers
1	6		6
2	6		12
3	4		12
4	4		16
5	2		10
6	2		12
7	0		0
8	0		0
9	1		9
10	1		10
14	1		14
20	1		20
Total	28	Total	121

employees, to subsidiaries of companies with many thousands. The business or products of these various firms ranged from airplanes to textiles, and they may be loosely grouped into the categories shown in Table 5. It should be noted, however, that regardless of the final product of the company, most of the blind workers were concerned with tasks using small machines or assemblies, and which could be adequately controlled by touch or sound.

Types of work. The questionnaire was constructed to group the workers into six major categories according to their type of work. These categories were: 1. assembly; 2. inspection; 3. machine operation; 4. packing, wrapping and crating; 5. disassembly; 6. sorting. A seventh group, other, was included for those jobs which did not fit well into any of the original six categories.

It was found, however, that many of the workers, such as repairmen, could be placed in two or more of the categories. For this reason, these categories were subdivided into those workers who performed this operation as the main portion of their job, and those who were engaged in this category as an adjunct, or a minor auxiliary part of their job. The distribution of the workers according to category of work and to whether this is their main task, or a sub-task, is given in Table 6.

Table 5

Kinds of Industries Employing Blind Workers

Business or Product	No. of Blind Employees
Business machines	5
Plastics	3
Electronics and electrical equipment	18
Film processing	6
Textiles	2
Aircraft	10
Furniture	8
Military bases	32
Bearings	20
Elevators	4
Valves	3
Aerosol cans	6
Other	4
Total	121

Table 6

Types of Work Performed by Blind Employees

Work Category	Main Task		Sub-Task	
	Number of Workers	Per Cent	Number of Workers	Per Cent
Assembly	34	28	1	.1
Inspection	22	18	8	.6
Machine operation	19	16	15	1.2
			24	1.9
Packing	16	13		
Disassembly	14	12		
Sorting	1	1		
Other	10	8		
No information	5	4		
Total	121	100		

When one considers the workers whose main task was one of the seven groups indicated, the following comments may be made of the group as a whole. Assembly and inspection accounted for most (46 per cent) of the workers. Packing, disassembly, and machine operation employed another 41 per cent, and the jobs grouped under "other" accounted for 8 per cent of the total. Only one of these jobs termed "other" and the one person employed in sorting could be properly called menial, unskilled work. The tasks of five workers were not indicated. It is therefore evident that, with the possible exception of two workers, these 121 blind employees are involved in tasks which require some degree of skill and concentration, even for the sighted worker. As will be seen later, at least two are employed in tasks requiring considerable skill and training.

It is entirely possible that these positive aspects of the type of task of the blind worker may constitute a biasing factor in this sample. That is, it is possible that only those companies which are employing the blind in skilled or semi-skilled occupations were willing to answer this questionnaire.

1. Assembly. Most of the assembly work involves small objects, both simple and complex. (See Table 7). These workers seem to find particular usefulness in the assembly of electronic parts and sub-assemblies, although some companies employ the blind in the manufacture of furniture and kitchen equipment. It

Table 7

Type of Assembly Work Performed by Blind Employees

As main task	No. of Blind Workers
Lamp sockets for switchboard	2
Spring subassembly for key stems of adding and calculating machines	3
Goggles and respirators	1
Thermostats	9
Picture frames	3
Oven doors	1
Small electronic parts	4
Knitting machine (insert small needles)	2
Drawer slides	1
Electronic equipment (also disassembles)	1
Bearings	1
Electronic parts	6
	34
Secondary to main task	
Telephone equipment	1
	1

should be noted that these small devices which the blind assemble permit extensive use of the tactile sense.

2. Inspection. Table 8 shows blind workers employed in the inspection of various types of mechanical devices, such as valves, aircraft ignition parts, and furniture. One company uses these workers in testing the hardness of various metals by drawing a file across the metal. In all of the operations, the companies have come to utilize the extremely well developed sense of touch, which is so commonly noted among the blind.

In addition, one company uses blind workers in the operation of an "electronic size gauge," but as the details of this operation were not given, one can only assume that this machine has either an automatic reject or an auditory warning device.

Many of the operators perform inspection as a sub-task of their main job, which is usually assembly and/or repair.

3. Machine operation. As shown in Table 9, these workers employ a wide variety of machinery in their work, ranging from hydraulic tube benders to drill presses. The majority of these machines use electric motors as a source of power. Ten workers use machines which cut or grind, and which presumably expose the operator to a certain, however minimal, hazard. It may be presumed that the accident record is no greater than that for the sighted workers, or the company could not afford to retain them.

Table 8

Type of Inspection Work Performed by Blind Employees

As main task	No. of Blind Workers
Valves	2
Furniture parts	1
Aircraft ignition parts (generators)	1
Bearing parts (for hardness with a file)	13
Bearing parts with electronic size gauge	5
	22
Secondary to main task	
Bearings	1
Photographic equipment	1
Airborne weapons	1
Aircraft ignition parts	4
Telephones	1
	8

Table 9

Type of Machine Operated by Blind Employees

Nature of Task	No. of Blind Workers
<u>As main task</u>	
Wiring & stripping machine	2
Pako film machine	4
Hard automatic processing machine	1
Cut-off saw	1
Vinyl cutting	1
Drill press	1
Drill press & grinding machine	2
Sander	1
Planer	1
Hydraulic tube bender	2
Bearing sounding machine	1
Bearing run-in machine	1
Bearing lapping (also cleans & inspects)	1
	19
<u>Secondary to main task</u>	
Automatic tacking machine	3
Public address system	2
Telephone	1
Electronic calculators (IBM), etc.	1
	7
<u>As objects of service & repair</u>	
Recording & transcribing equipment	1
Photographic equipment	1
Airborne weapons	1
Aircraft ignition parts	4
Telephones	1
	8

It should be noted that those workers using cutting and grinding machines do so as a main part of their job and that the machines which do not have motors are generally used as adjuncts to the worker's main task. Eight blind workers not only operate machines, but as a secondary task also service and repair them.

The gauges and testing machinery used by blind workers operating machines are equipped with automatic reject devices, or tonal scales. It is of particular interest that one company has been able to modify its existing test equipment to give an auditory "reading" by the use of a tonal scale.

4. Packing, wrapping and crating. Table 10 shows the number of blind workers employed in each of the remaining categories, with a total of 16 blind people engaged in packing, wrapping, and crating. Packing and crating may, for the most part, be considered as fairly unskilled tasks, requiring little judgment or skill. The task of wrapping may, however, require a certain amount of judgment and skill, unless the job is so highly routinized that it presents the worker with relatively few unexpected situations. It is, however, self-evident that the wrapping of small delicate parts requires, if nothing else, particular care and caution. In any event, this sort of task would depend, for the blind worker, mostly upon the sense of touch.

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[illegible]

[illegible]

Table 10

Further Tasks Performed by Blind Employees

Packing, Wrapping and Crating	No. of Blind Workers
Ribbon	1
Hardware	2
Aerosol cans (into display cartons)	6
Pencils	1
Delicate instruments and gauges	2
Small aircraft parts and accessories	2
Valves	1
Automobile spare parts	1
	16
Disassembly	
Electronic equipment	3
Ignition harnesses	2
Small aircraft parts	8
Aircraft generators, starters and alterators	1
	14
Sorting	
Nuts, bolts and washers	1
Other	
Electronics engineer	1
Typist (transcribing recordings)	1
Public address operator	2
Manual processing of X-ray films	1
Aircraft armament repair (turrets, rockets, missile pads, etc.)	1
Telephone repairing	1
Conducts a class in the use of electronic accounting machinery (IBM), etc.	1
Electroplating	1
Janitor	1
	10

[illegible]

[illegible]

5. Disassembly. This category was added after the initial inspection of the questionnaires. For the most part, this disassembly is concerned with mechanical devices, although it may require the use of a soldering iron in some instances. These tasks again demonstrate the use of the blind worker's tactile sense as a substitute for his visual sense.

6. Sorting. Only one person was listed by a respondent as being employed in a sorting operation. This was an Air Force base employee who sorts nuts, bolts and small fittings.

7. Other. A wide variety of jobs are included in the category of "other." Probably the most noteworthy are the instances of an electronics engineer, and a man who conducts a class in the use of IBM-like accounting machines. The details of training were not given in either case, but it is highly probable that these men became blind after they had received their education, although this conclusion is by no means mandatory.

The company employing the IBM machine instructor has made special modifications of their equipment, such as raised circuit diagrams, etc. The other company has indicated no special equipment.

Two other workers of this group are repairmen; one servicing airborne armament, and the other repairing telephones.

Again no details of training were given, but it may be fairly safely conjectured that these men use essentially the same equipment as any other worker.

The switchboard, telephones, and transcribing machines are again, machines which can be run by touch and sound alone, with a little practice, and do not require the use of sight.

The final occupation listed under this category is that of janitor. For the sighted person this is relatively menial work, but for a blind worker this type of work may well present complex difficulties far greater than those encountered in seated routine assembly, or inspection or the like.

Innovations and Changes. A request was made in the questionnaire for a summary of the changes and innovations which were made in the machinery and/or work methods for the benefit of the blind workers. Forty-six per cent (13) of the companies employing blind workers gave a definite answer to the question, while 15 firms left the question blank (see Table 11). One of the 15 companies leaving the question blank did, however, indicate in a job description elsewhere on the questionnaire that a blind worker engaged in an edge grinding width machine operation used a Braille micrometer.

Table 11

Answers to Questionnaire Question III Covering Changes and Innovations Made in Work Environment for Blind Workers

Kind of Information Given	No. of Companies Answering
No reply to question	15 *
Information given not pertinent	3 **
No changes made	4
Changes not significant	1
One change reported	3
Two changes reported	2
Total	28

* Use of Braille micrometer reported elsewhere on questionnaire by one firm.

** One of these 3 firms gave answer implying machine modification.

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[illegible]

[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Three of the 13 firms giving a reply answered with a statement that was not pertinent or failed to give the desired information. One of these three said "We try to build tools to suit their [the blind workers'] dexterity," implying that adaptations or changes <u>are</u> made in that plant for the blind employees.

Four firms stated that no changes had been made, and one, that any changes made had not been significant. Five other firms admitted to modifications or innovations, with two of the five reporting two changes each.

If we can assume that the firms who failed, even by implication, to note modifications or innovations did so because they had made no changes, then 21 or 75 per cent of our sample made either slight or no change in their equipment to accommodate the blind worker.

The five companies answering question 3 in some detail modified their existing machinery but did not purchase any different type of machinery (see Table 12). One company adapted auto-nailer machines "so blind workers could operate them as well or better than a sighted person." Two others used sonic indicators to replace visual dials. In one of these firms a system of tones to indicate critical tolerance replaced gauge indicators for visual inspection. In the other, a blind worker testing radio and electronic tubes used test equipment designed

Table 12

Changes Made in Work Environment of Blind Workers as Reported in Questionnaire by Five Firms*

Innovations and Changes	No. of Companies
In Machinery and Equipment	
Automatic Nailer (Tacker)	1
Electronic testing equipment -- substitution of sound or tonal indicators for the usual visual indicators	2
Raised charts and mock-ups	1
In Methods	
Modification of work operation	1
Rearrangement of work area	1
Special supply procedure	1

* Two firms reported two changes each.

by his superior which worked through the use of sound only, rather than by the conventional sight method.

Another reported provision of mock-ups and charts with raised impressions for their blind employee who acted as a training instructor in the operation of electrical accounting machines. "The use of these training aids, while not visible to the instructor, allows him to instruct his students through their visual observation of complicated wiring diagrams, and difficult operational procedures."

Three firms indicated modification of work operation and rearrangement of work area, or changes in stock distribution. One company wrote as follows: "Two operations of spinning and tinning done on stranded wires ordinarily are performed by one operator. This has been broken down so that the blind operator only spins the wire, since the firm felt that the tinning operation, which involves a hot solder pot, would be dangerous."

Another plant had rearranged work areas to permit blind employees to reach bearing parts easily, and to distribute finished work in proper containers; and one delivered stock to the blind worker, although his sighted cohorts were responsible for going after their stock.

Question IV, which requested a description of the most significant change or adaptation made, was answered by seven

of the 28 companies who employed blind people. The other 21 firms left it blank. Of the seven who answered, three made replies as follows:

> "No outstanding changes have been made."
>
> "No special devices or other aids are used by these persons; they are merely placed where their handicap has no bearing on their job."
>
> "No changes -- our blind employees use the same tools as those with sight."

The firm which had adapted the auto-nailer machine considered making this "injury-proof" their most outstanding change. Both of the companies which had substituted tonal systems for visual indicators on their equipment referred to that adaptation as the most significant. One commented: "It provides for the replacement, by a blind employee, of an employee who can thus be utilized in other work areas." Finally, a film processing plant wrote that the most important factor was convincing employer and/or supervisor that a handicapped person could do the job equally well or better.

Future Work

Many firms in the United States have had, but now no longer employ, blind workers. A poll of such companies might

provide much meaningful information for those involved with placement of blind people in industry. Main objectives of such a survey might be to determine the length of time blind employees had been with the firm, the reason for their leaving, and management's reason for hiring no blind since then.

Best results for this type of survey would probably be obtained either by personal interview or the provision of anonymity for the companies who answered in writing.

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SECTION VI: VISITS TO PLANTS

Plant Visit I

General Information

This visit was made to a firm engaged in wholesale photo finishing. Two blind people are employed, a man and woman. Both obtained the jobs through individual application, rather than agency referral. The man works six days a week, and the woman five.

Description of Observed Tasks

Both blind employees work in the plant as film strippers. They work in a darkroom. Film racks, loaded with rolls of film needing to be developed, enter the darkroom on a conveyor belt. The film is "stripped" from the film clips on the rack by the blind workers, who then turn around and place each rack on a machine directly behind them called the Pako Senior Film Processing Machine. All work is done while standing.

Both the blind workers and any sighted employees who enter the darkroom use an electric light switch to signal readiness for entry of loaded conveyor belts into the darkroom, which must be unlighted when film enters. A bulb placed just outside the darkroom, at the point of entry for conveyor belts, goes out when the darkroom is lighted. The conveyor belt is then stopped. When this bulb light (signalling that lights are off in the darkroom inside) movement of the conveyor belt resumes.

Comments

The foreman reported that closer and more frequent supervision of the blind employees was required than for sighted workers in the same jobs, but this disadvantage was offset by

another factor. The varying periods of idle time in the darkroom which occur while waiting for loaded racks are apt to be spent by sighted employees in roaming the plant and talking, wasting the time of the other personnel. Both blind employees, however, tend to remain in the darkroom when there is no work to be done. The woman "reads" magazines during this period, and the man sweeps the floor of debris, or cleans film clips of bits of paper which have adhered, the latter duties being ones which the sighted personnel do not tend to perform.

A stool placed in the darkroom would make these periods of enforced idleness more restful. Also, an auditory signal denoting passage of time would be helpful.

The foreman was emphatic that both these employees were as good as sighted workers, the woman especially being extremely hard working, fast, neat, and one of the best persons ever employed by the plant in her job.

This firm answered the item on the questionnaire asking for the most outstanding or significant change or adaptation in the following manner: "The most important factor was to convince employer and/or supervisor that a handicapped person could do the job equally well or better."

Plant Visit II

General Information

The work done at this factory consists mainly of assembly of electronic cable. The firm employs four blind men among its regular personnel. The blind workers all perform various jobs, and are changed occasionally from job to job. The personnel manager pointed out that this procedure is not unique to their handicap. As is usually the case in a plant where orders vary, the workers in the department where work has slackened are moved to another area. (During a year's time this may mean only five or six moves)

Description of Observed Tasks

Worker #1 spot ties and guides the cable in slots, from point (nail) to point (nail), on a schematic print laid out on a board called a "jig." When there is an odd nail, or one out-of-line, this indicates to him that it is the point to "tie-off" one of the leads. Sometimes he may start out with ten strands, and after tying off the leads at the various points, finish up at the other end of the cable with only four strands. The cable is wound around the board, rather than stretched out flat, to allow the worker to remain seated and to provide a compact workspace. As each cable is finished, it is lifted from the jig and put into a box or bin. Another is then started.

This man was working in the same manner as his co-workers, with no special tools. When work is to begin on a different print, he is given the first briefing separately by his foreman,

at which time he takes notes in Braille, and then memorizes the layout. "Quantity" orders are channeled his way in order to eliminate stopping and re-memorizing as much as possible.

Since this worker judges the length of strands by feel, on quantity orders where he has had an opportunity to master the "feel" and work up speed, this employee could equal or surpass sighted workers who judge by sighting the strand along the nails.

Worker #1 had been in industry for 15 years.

Worker #2, who works in electronic chassis assembly, is an excellent operator and is often requested by various departments, because of his flexibility. He does all types of electrical assembly, including cabling and wiring, and maintains his own tool box, in which he has all the applicable items on the market for the blind worker. For illustration, he showed a regular steel tape measure with raised numbers, a micrometer with special attachments, and a vernier caliper.

On his own initiative, this man prints instructions for tasks in Braille so that any of the blind employees in the shop will be able to work on these jobs whenever called upon to do so.

It was noted by the interviewer that the hot soldering equipment located near the bench of this blind worker had been enclosed in a protective mesh covering, a safety device established especially for him.

On occasion this worker requests that a particular jig be made for a job, and "the company has gone along with him 100 per cent." Since his requested modifications are in the nature of simplification or additional speed, they have benefited the

other workers also, and have been adopted for their use. Without realizing it, this employee is applying many of the principles of human engineering to his work.

Worker #3 also works on electronic chassis assembly. Unlike the other blind employees, he had been without sight for only eight years, but had been in industry a total of 25 years. He is also partially deaf and wears a hearing aid. Of the four blind people in the plant, this worker was the only one with a seeing-eye dog. During working hours the dog stays in a nearby empty washroom, within whistling distance.

When questioned, Worker #3 mentioned only one instance where he had changed a task from the way it had been set up originally. This was to "take a shortcut" in putting on sockets, which was promptly adopted also by the sighted co-workers.

This employee had built his own short-wave radio set and holds an amateur's license.

On the particular day of the writer's visit Worker #4 had been put on a task of counting and cutting into lengths the strands of wire which would later go into the cable in another process. Although this man's work production was considered satisfactory, personnel records showed him given to self-pity and lax in personal cleanliness, fellow workers having reported him several times on the latter point.

Comments

The personnel manager of this plant cited the production records of the four blind workers, showing that three of them performed above average and the remaining individual on an

average level. He thought the higher production due in part to two factors, the first being motivation...the determination to do a good job, plus the knowledge that a job change for them would not be as simple as for those with normal vision. Secondly, he expressed the opinion that their "lack of distractions" contributed to the superior performance of three of the blind workers.

Item 3 on the questionnaire (changes or innovations in equipment or environment) brought the following answer: "We try to build tools to suit their dexterity...the employees involved suggest methods of their own that would be helpful to their performance of work. Any suggestions they may have we accept and act upon accordingly." Plant inspection and management attitude at the time of the visit tended to confirm these statements rather positively.

average level. He thought one of the [illegible] in part [illegible] factory, [illegible] the [illegible] [illegible] a good job, [illegible] knowledge than a job change [illegible] [illegible] not be [illegible] with normal vision. Secondly, [illegible] expressed the [illegible] "lack of interaction" con- [illegible] to the [illegible]

[illegible].

He [illegible] on the [illegible] (changes or innovations) [illegible] equipment or [illegible] answer: [illegible] try [illegible] tools [illegible] the [illegible] involved [illegible] methods of [illegible] own [illegible] might [illegible] work. [illegible] suggestions [illegible] [illegible] Plant [illegible] tended to confine [illegible]

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Plant Visit III

General Information

A large furniture factory had returned their questionnaire with a listing of four blind workers, one of whom worked in the office section operating a typewriter and dictaphone. Since it had earlier been decided to exclude office machines from the study, this employee was not observed during the visit to the company. A second employee, who had worked in machine operation on a planer, had left the firm to take a better job. Of the remaining two blind personnel, one was employed as a chair component assembler. The other worked as a parts inspector, and also assembled drawer guides. One of these men had been with the firm two years, the other five.

All of the blind workers had been placed in the plant by the State Commission for the Blind, under the supervision of a placement manager who is himself blind, who learns each job before he places people in it, and who expresses a philosophy of no special provisions for the blind worker.

Description of Observed Tasks

The component assembler obtained his large materials from three bins placed approximately 15 feet from his workplace. He stood during the entire workday. Small components were on his bench in boxes above his lap and at the back of his bench. Finished assemblies were placed in a pile to his left. The complete assembly totaled approximately 25 suboperations, resulting over-all in a task which would have cost many thousands of dollars to automatize.

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Although the wood materials with which this man worked had been through numerous suboperations and inspections, some of the components were defective, apparently due to faulty inspection. In most cases the blind worker was able to detect even very minor defects, but on a few occasions made a complete assembly which was later judged to be a reject.

A possible reason for the faulty inspection processes may have been the considerable ambient dust in the building, which might have covered cracks and blemishes in the woods. Also, the none-too-bright lighting could have caused shadows which made observation of defects difficult, particularly late in the day during the winter season.

The second worker performed an assembly job at a bench, after obtaining major components from a bin about ten feet away. Dowels from a large random bin were inserted, following the application of glue by means of a glue-gun positioned by hand. Finished pieces were stacked on the bench in groups of four.

In this operation it was essential for the blind worker to discriminate the various sizes of dowels.

Here too, previous imperfect inspection processing of the wood components occasionally resulted in wasted work by the blind assembler.

It might be possible to cheaply automatize the job of this second blind operator, but a sighted machine tender-inspector would then be essential.

Comments

Several modifications of the work environment are possible in the operations just described. Placement of raw materials nearer at hand to workers conserves personnel time and energy. Stools available for occasional sitting lessen fatigue. Prepositioned dowels and a compartmentalized bin should facilitate handling and counting of the dowel pieces. Two changes in the design of the glue gun would make its operation more efficient; i. e.,a quantity measuring device to cut off the amount applied, and a guide for simplifying its position in the dowel hole.

PLANT VISIT IV

General Information

The factory toured on this visit was a large plant making automobile parts. It employed three blind middle-aged men, all engaged in machine operation, as hydraulic tube benders. Their supervisor reported them to be steady workers, with little absenteeism. In addition to his regular factory job, one man is a tax collector in the nearby community where he lives, and commutes daily to work, a distance of several miles. Two of the men were blinded in plant accidents, in the factory where they now work, and a third was sightless when hired. All work regular hours and keep the same schedule as other plant employees.

Description of Observed Tasks

The blind workers handle a large part of the tube bending done in the plant, including work on some tubes with ten bends, which involves eight complex movements and walking a distance of over ten feet. They operate not only the hydraulic bending machines, but at times alternate on the hand benders. In both instances, long lengths of small diameter tubing are bent into various shapes for use as gas lines and fuel lines for automobiles.

An assistant makes boxes for the blind workers and helps to provide them with raw materials. (The completed questionnaire from this firm stated that the only change made in routine for the benefit of blind employees was delivery of stock.) The assistant also maintains the equipment, which is subject to frequent breakdown.

The majority of the work requires fine dexterity, and some of the jobs performed necessitate extreme strength exertion for both the sighted and blind workers. Factory environment was relatively noisy and greasy.

Shifts to new jobs are not unusual; and often the blind personnel are kept on them for only a few days. In spite of this, information given the interviewer indicated that they frequently produce 50 per cent over the normal rate for sighted workers.

Comments

Guide rails or ropes would be useful at this plant for aiding the blind workers to move to and from their workplaces. Other changes which might be made would help increase efficiency, production and safety for all plant employees. Examples are organization of raw materials and finished products into standard positions, reduction in human force requirements, reduction of noise level, and installation of safety guards on machines. Too, footing throughout the building could be made less slippery if more rigid housekeeping requirements were enforced.

PLANT VISIT V

General Information

The two blind workers in this factory were employed in machine operation on a (stocking) knitting machine. They were men of middle age who appeared alert, healthy, and well-dressed. Both read Braille with ease, and write with the aid of a Braille guide. Neither had used guide dogs. One is a ham radio operator in off-duty hours. One had read much about Abilities, Inc., and felt that there was no reason why blind people could not operate presses or other factory equipment.

Both employees ride car-pools to the factory. Upon arrival at the door of their building they are taken by service elevator to the floor where they work. At closing time, these men punch out a few minutes early in order to avoid the common time-clock rush.

Description of Observed Task

The blind personnel perform assembly work on a typical factory bench in a relatively quiet bay-type space. Numerous sighted workers occupy the same bay.

Needles are inserted in needle bars for full-fashioned knitting machines which make full-fashioned ladies' hose. The actual operation consisted of reaching for approximately 12 needles in a box on the work bench. Needles are two inches long with a diameter of approximately one sixty-fourth inch, and a 90 degree bend about one-quarter inch from the non-pointed end.

After being picked up, the needles are inserted one by one into a needle bar in units of 100. After completion of a bar it is moved to the front and right of the bench working area.

From time to time the men work on different sizes. No apparent changes in workplace had been made from that used by the sighted workers performing similar operations.

The two blind employees had each developed crude but ingenious counters by means of which to keep a record of their production, in units of bars completed. These consisted of a pivoted arm which moved along on brads of arbitrary value. One worker also had a card file of Braille cards for keeping detailed personal records.

Although the actual production rate of the blind employees was not revealed, it was indicated as being as high or higher than that for comparable sighted personnel. The personnel director reported both men as steady, dependable operators whose presence stimulated fellow sighted workers to increased production.

Comments

Possibilities for improvement in this work situation, for all workers, include the introduction of a jig for holding the needles in a precise organized location, rather than being positioned randomly in a box-like container; and accentuation of the grooves in the needle bar into which the needles are placed. A greater taper to the needles, and machine inspection to insure their perfection would also seem to be helpful. A specific location in which finished needle bars could be stored would lessen or eliminate damage to the needles.

[illegible]

A tactual counter, and raised serial numbering on the needle bars could be added, and would be useful to the blind workers. For the sighted, improvement of lighting, including not facing glare sources, would make seeing less difficult.

Feasibility of Human Engineering For Blind Industrial Workers

Human engineering, as applied to the blind employee in industry, may be used in various ways to adapt jobs to correspond with the abilities of the blind worker. In brief summary, methods of accomplishing this may be done by:

(1) Making a slight change in the working arrangement;

(2) Making adaptations to standard tools and equipment which are characteristic of an industry;

(3) Supplying the worker with special tools or convenient devices for his own use.

It was interesting to note that both during the plant visits and in the questionnaire returns considerable resistance was expressed by blind workers and management to adaptations and changes. Typical is the following quotation from the questionnaire returned by a midwest manufacturing firm: "Our blind workers want no special favors. They adapt themselves to conditions they find. If we made extensive modifications of our equipment, plant or other working conditions, they would resent it as an insult to their ability." In another firm the foreman commented that management respected the wishes of the blind men: "want no special privileges, give no special privileges." To combat and change this attitude, industry and worker must be helped to understand that what is good for the blind worker is usually an improvement for everyone concerned.

To illustrate, a perusal of the description of the plant visits made during this study will show the great majority of

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the changes made or suggested to be ones beneficial not only to blind workers but also to the sighted.

This point, that many changes which benefit the blind will help all workers, is of major importance in the attempt to reduce employer resistance to hiring sightless personnel.

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SECTION VII: RECOMMENDATIONS. SUMMARY AND CONCLUSIONS.

Recommendations

Individual Provision of Modified Tools and Equipment

Many factories and industries have work that can be successfully performed by blind employees, if such individuals have available to them tools and equipment modified to meet their particular needs. It is unrealistic to expect employers to take the initiative or expend time and money in supplying such equipment. Yet, too few blind applicants make the effort to determine and obtain the type of modified tool or equipment suitable for the specific job for which they are applying. Sometimes of course, it is impossible to do so. In many instances, however, it is possible for a blind person to apply for work with the proper instrument to perform the job, already adapted, in his possession. The possession and demonstration of such modified tools or equipment will do much to convince an employer of a worker's know-how and grasp of the job for which he is applying.

Such aids to prospective blind employees exist in quantity. Unfortunately, too few blind persons are aware of their existence or make as great use of them as they might.

Greater Use of Special Services

Undoubtedly the largest collection of technical devices of aid to the blind (in all phases of daily living, as well as the vocational) exists in the Special Services Section of the

American Foundation for the Blind. This department (originally called the Technical Research Department) was set up in 1946 and is headed by Charles D. Ritter, a remarkable man whose interests center in the development of ingenious and practical devices to aid the blind in the conduct of their private lives and in earning a livelihood. It is due to Ritter's untiring enthusiasm and mechanical ingenuity that the Service is used to the degree it is and has developed as great a variety of aids as it has.

Several functions are performed by the Special Services Section. Within it, commercial products are adapted to the needs of the blind, and various tools which blind people have invented but lack the financial resources to manufacture, are put into production. Aids for the blind which do not require any special adaptation but are not otherwise generally known as aids, are publicized by Special Services through various publications received by the blind. Its ultimate aim is the "existence of a real clearing house where the blind individual with a special problem can turn to find out what others have already done toward the solution of the same problem." (Zahl, 1950)

A catalog of devices available from the American Foundation for the Blind is published periodically by Special Services. Its title is "Aids for the Blind."

A quick perusal by the writer of the approximately 30 items listed for sale in the catalog (June, 1957) under the

heading "Tools," showed 26 available for purchase at a cost of less than five dollars, two ranging in price between five and ten dollars, and five other items quoted in the twenty-to-thirty dollar price range.

In the foreword of the sixth edition (June,1957) of the Special Services catalog appear the following significant statements:

"Those who encounter problems for which there does not appear to be a solution in this catalog are advised, nevertheless, to submit the problem to Special Services. Often a special device may be constructed; and even more often a special technique may be suggested. Blind people in all sorts of trades and professions cooperate in disseminating such techniques; and this pooling of experience can prove to be among the greatest of "Aids for the Blind."

Comment

New Public Image

Before employment of the blind in industry can become more prevalent, certain specific problems (see pages 23 - 27) must be met and solved. However, probably the greatest obstacle to placement of the blind still is the emotional attitude of the public. To many, blindness means tin cups, pencils for sale, dark glasses, white canes, and seeing-eye dogs. Such stereotypes influence the lives and welfare of the blind, not only in

industrial employment, but in all aspects of living.

A large-scale well-directed propaganda campaign could do much to educate the public and improve the status of the sightless. Publicity of all kinds should present blind individuals as men and women who can contribute to the productivity of society.

A sighted public thus made aware of the capabilities and potentialities of the blind can do more to help them than can any number of institutions and shelter workshops.

Summary and Conclusions

The project reported here was conceived as a small-scale or pilot study, with two principal aims: (1) to ascertain the extent to which industries employing the blind have applied the principles of human engineering to the design of the machines or workplaces used by their blind workers, and (2) to define ways in which human engineering might make employment of the blind practical.

After some preliminary work, it was decided to limit the scope of the study in two ways. The first decision concerned the review of literature, which it was felt wise to confine to material dealing with the blind in this country. Second, it was decided to give attention only to operations performed, and machines used, in industry, and exclude business and office activities and machines.

For purposes of this research, the definition of blindness used was vision of 20/200 or less in the better eye with correction.

The study was divided into three phases: (1) review of the literature, (2) survey of industries by questionnaire, and (3) visits to factories employing the blind.

The review of literature yielded very little information on the blind worker in industry, but the authors did find evi-

dence that there is a large mass of newspaper and magazine material reporting innovations devised by blind individuals who have overcome difficulties confronting them on their jobs. It is the opinion of the writers that the collection of that portion of this ephemeral material which deals with positions in industry, might be extremely worthwhile as an aid in furthering future employment of the blind.

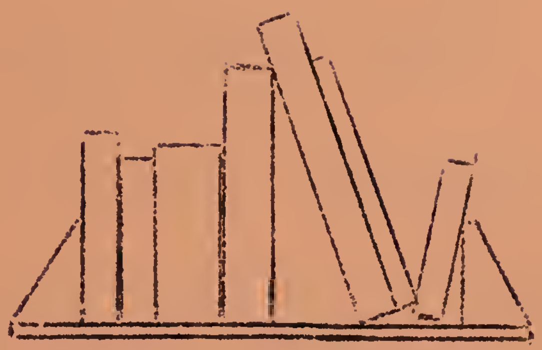
The survey phase of the study included the mailing of 178 questionnaires to factories throughout the United States. Of these questionnaires 124 went to plants which were known to have been employers of the blind. A group of 54 firms selected at random, not definitely known to have blind personnel, were also mailed questionnaires. Information asked for included the number of blind workers employed, kinds of work being done by them, and description of innovations or changes made on the job. Returns were received from 68 companies, 28 of which had blind personnel on the payroll. Five firms reported that blind workers were using tools or machinery which had been modified in some way. These modifications are described.

Visits were made to five of the companies returning affirmative replies. In only one of these was there found examples of human engineering having been applied to the workplace, and in all of the companies, instances were observed where further applications might well be made. Both questionnaire results and plant

visits indicated that, although very few of those who employ blind workers had made an attempt to redesign the machine or the workplace used by blind employees, a systematic program of human factors engineering would yield beneficial results to the employer, the sighted worker, and the blind employee.

visits indicate [illegible] who employ blind workers [illegible] machine or the workplace [illegible] employees, a [illegible] program of human factors engineering would yield benefit[illegible] result[illegible] the employer, the sighted worker, and the blind employee.

SECTION VIII: SELECTED BIBLIOGRAPHY



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Smith, Lollar F. _The adjustment of the blind to industrial employment_. Master's thesis, Washington Univer., St. Louis, 1945.

Switzer, Mary. _Testimony given during hearings before a subcommittee of the Committee on Education and Labor, House of Representatives_. Washington, D. C., July 31, 1957.

Training and employment data on 1003 blinded veterans of World War II. New York: Amer. Found. for the Blind, Inc., Bull., 1951.

Occupations of totally blinded veterans of World War II and Korea. Washington, D. C.: Veterans Administration, 1956.

Zahl, P. (Ed.) _Blindness--modern approaches to the unseen environment_. Princeton: Princeton Univer. Press, 1950, P. 15, 206-233, 394, 431-442.

SECTION IX: APPENDICES

APPENDIX A

Names of Firms Sent Questionnaires

Names of 178 Firms Sent Questionnaires

ACF Electronics
1305 Leslie Ave.
Alexandria, Va.

Aircraft Armaments, Inc.
Industry Lane
Cockeysville, Md.

Allen-Bradley Co.
136 West Greenfield Ave.
Milwaukee, Wisc.

Allis-Chalmers Mfg. Co.
1126 South 70th St.
Milwaukee, Wisc.

American Bosch Arma Corp.
Arma Division
Roosevelt Field
Garden City, Long Island, N.Y.

American Cyanamid Co.
Calco Chemical Division
Bound Brook, N. J.

American Instrument Co.
8015 Georgia Ave.
Silver Spring, Md.

American Machine & Foundry Co.
1101 N. Royal St.
Alexandria, Va.

Anchor-Hocking Glass Corp.
Salem, N. J.

Anderson & Forrester
3563 Larimer St.
Denver, Colorado

Armstrong Cork Co.
Lancaster, Pa.

Arrow-Hart & Hegeman Elec. Co.
103 Hawthorn St.
Hartford, Conn.

Associated Craftsmen, Inc.
15 Emerald St.
Hackensack, N. J.

Auto Fuel and Ignition Co.
3315 River Rd.
Columbus, Ga.

Auto Specialties Corp.
St. Joseph, Michigan

George H. Barr and Co.
36th and S. Racine Ave.
Chicago, Illinois

Beau Brummel Ties, Inc.
440 E. McMillan St.
Cincinnati 6, Ohio

Bell Aircraft Corp.
P. O. Box 1
Buffalo 5, New York

Bendix Aviation Corp.
1200 E. Joppa Rd.
Towson 4, Md.

Bendix Aviation Corp.
95th and Troost Aves.
Kansas City, Mo.

The Black & Decker Mfg. Co.
E. Pennsylvania Ave.
Towson 4, Md.

Boeing Aircraft Co.
Wichita Division
Wichita, Kansas

Breco Manufacturing Co.
309 E. Saratoga
Baltimore, Md.

Breeze Corporations, Inc.
700 Liberty Ave.
Union, New Jersey

The Budd Co.
2450 Hunting Park Ave.
Philadelphia 32, Pa.

Burroughs Adding Machine Co.
6071 Second Ave.
Detroit, Michigan

Columbus General Depot
Columbus, Ohio

Corning Glass Works
Corning, New York

Corona Corp.
346 Claremont Ave.
Jersey City 5, N. J.

Crown Photo Service
1034 31st St., N. W.
Washington, D.C.

C. R. Daniels, Inc.
75 West St.
New York 6, N. Y.

Daystrom Instrument Co.
Archibald, Pa.

DeLaval Separator Co.
Poughkeepsie, N. Y.

Joseph Dixon Crucible Co.
167 Wayne St.
Jersey City 3, N. J.

Douglas Aircraft
3000 Ocean Park Blvd.
Santa Monica, Calif.

Duquesne Mine Supply Co.
2 Cross St.
Pittsburgh 9, Pa.

Eastman Kodak Co.
343 State St.
Rochester 4, N. Y.

Nickolas Eckerlin
New Rochelle, New York

Esterbrook Steel Pen Co.
Delaware Ave. & Cooper St.
Camden, New Jersey

Excelsior Hardware Co.
39 Woodland Ave.
Stamford, Conn.

E. E. Fairchild Corp.
367 Orchard St.
Rochester 2, N. Y.

Fairchild Engine & Airplane Corp.
Hagerstown, Maryland

Fafnir Bearing Co.
37 Booth St.
New Britain, Conn.

Federal Laboratories, Inc.
Saltsburgh, Pa.

Fletcher Enamel Plant
Dunbar, W. Va.

Fort Pitt Mfg. Co.
1501 Preble Ave.
Pittsburgh 33, Pa.

Foster Bros. Mfg. Co.
320 N. Holliday
Baltimore, Md.

Foster Engineering Co.
835 Lehigh Ave.
Union, New Jersey

Foster Wheeler Corp.
165 Broadway
New York 6, N. Y.

Frankford Arsenal
Philadelphia, Pa.

Frankoma Pottery Co.
Sapulpa, Oklahoma

Gabriel Company
14500 Darley Ave.
Cleveland, Ohio

The Garlock Packing Co.
402 E. Main St.
Palmyra, N. Y.

General Hospital
22nd & McCoy
Kansas City, Mo.

General Motors
Chevrolet-Cleveland Div.
Brookpark & Stumpf Rds.
Parma, Ohio

General Motors
Oldsmobile Div.
Lansing, Michigan

General Railway Signal Co.
801 West Ave.
Rochester 2, N. Y.

Geneva Forge, Inc.
Lehigh St.
Geneva, N. Y.

Gerotar May Corp.
Maryland Ave. & Oliver
Baltimore, Md.

Greer Hydraulics Inc.
N. Y. International Airport
Jamaica 30, N. Y.

Gould Pumps, Inc.
Seneca Falls, N. Y.

Hackley Hospital
Muskegon, Michigan

Hamilton Watch Co.
Columbia Ave.
Lancaster, Pa.

Hammermill Paper Co.
1453 East Lake Rd.
Erie 6, Pa.

H. J. Heinz Co.
P. O. Box 57
Pittsburgh 30, Pa.

Hughes Aircraft Co.
Culver City, Calif.

Hurley Machine Co.
Cicero, Illinois

Ideal Brass Co.
250 E. 5th St.
St. Paul, Minn.

Industrial Parts Inc.
3383 East Layton Ave.
Milwaukee, Wisc.

Ingersoll-Rand Co.
Painted Post, N. Y.

International Harvester Co.
Evansville, Indiana

Jacobs Aircraft Engine Co.
750 Queen St.
Pottstown, Pa.

Johnson & Johnson
501 George St.
New Brunswick, N. J.

Kollsman Instrument Corp.
80-08 45th Ave.
Elmhurst 73, N. Y.

Koppers Company
Metal Products Division
200 Scott St.
Baltimore, Md.

H. W. Lay Foods, Inc.
Greensboro, N. C.

Lima Ordnance Depot
Lima, Ohio

Lord Mfg. Co.
1635 W. 12th St.
Erie, Pa.

McCormick & Co. Inc.
Light & Barre Sts.
Baltimore 2, Md.

McDonnell Aircraft Corp.
Box 516
St. Louis 3, Mo.

McDowell Mfg. Co.
301 Station Ave.
Pittsburgh 9, Pa.

Mallinckrodt Institute of
Radiology
St. Louis, Mo.

P. R. Mallory & Co.
3029 E. Washington St.
Indianapolis, Ind.

Glenn L. Martin Co.
Baltimore 3, Md.

Marvel Industries, Inc.
Sturgis, Michigan

Maryland Shipbuilding and
Drydock Co.
P. O. Box 537
Baltimore 3, Md.

Silas Mason Co., Inc.
P. O. Box 323
Grand Island, Nebraska

Maywood Air Force Depot
Cheli Air Force Station
Maywood, Calif.

Melpar, Inc.
3000 Arlington Blvd.
Falls Church, Va.

Midwest Biscuit Co.
Burlington, Iowa

Midwest Chandelier Co.
N. Kansas City, Mo.

Mine Safety Appliances Co.
201 No. Braddock Ave.
Pittsburgh 8, Pa.

Minneapolis Honeywell
Regulator Co.
2753 Fourth Ave. So.
Minneapolis, Minn.

Minneapolis Tool and Die Co.
615 Fourth Ave. So.
Minneapolis, Minn.

University of Minnesota
Minneapolis 14, Minn.

John Morrell & Co.
208 So. LaSalle St.
Chicago 4, Ill.

Mutual Brief Case Co.
135 Kossuth St.
Newark, N. J.

Mycalex Corp. of America
125 Clifton Blvd.
Clifton, N. J.

National Cash Register Co.
Dayton, Ohio

National Pneumatic Co.
125 Amory St.
Boston 19, Mass.

NEMS-Clarke, Inc.
921 Jesup-Blair Dr.
Silver Spring, Md.

Newark Paper Box Co.
228 High St.
Newark 2, N. J.

Northrop Aircraft
1101 E. Broadway
Hawthorne, Calif.

Ogden Air Materiel Area
Hill Air Force Base
Hill Field, Utah

Okonite Co.
220 Passaic St.
Passaic, N. J.

Oldbury Electro-Chemical Co.
5001 Buffalo Avenue
Niagara Falls, N. Y.

Olin Industries Inc.
New Haven, Conn.

Oneida Ltd.
Kenwood Station
Oneida, N. Y.

Onondaga Pottery Co.
1858 W. Fayette St.
Syracuse 4, N. Y.

Onyx Oil & Chemical Co. Inc.
190 Warren St.
Jersey City 2, N. J.

Otis Elevator
35 Ryerson St.
Brooklyn, N. Y.

Pangborn Corp.
20 Pangborn Blvd.
Hagerstown, Md.

Pemco Corp.
5601 Eastern Ave.
Baltimore 24, Md.

Penn-Union Electric Corp.
315 State St.
Erie, Pa.

Peterson Mfg. Co.
2716 E. 14th St.
Kansas City, Mo.

Philco Radio Corp.
Sandusky, Ohio

D. S. Plumb Co., Inc.
73 Norfolk St.
Newark 3, New Jersey

Price-Pfeister Brass Mfg. Co.
3011 Humboldt
Los Angeles, Calif.

Pyro Plastics
Union, N. J.

Queen Stove Works
Albert Lea, Minn.

Reed Roller Bit, Inc.
6503 Navigation
Houston, Texas

Reliance Picture Frame Co.
158 West Clinton St.
Dover, N. J.

Renwal Toy Corp.
Old Country Rd.
Mineola, N. Y.

Republic Aviation Corp.
Conklin St.
Farmingdale, L.I., N. Y.

Republic Steel Co.
1405 Republic Bldg.
Cleveland 1, Ohio

Republic Steel Co.
Truscon Steel Div.
1130 Albert St.
Youngstown, Ohio

J. E. Rhoads & Sons
2100 W. 11th St.
Wilmington 99, Del.

Ritter Co., Inc.
400 West Ave.
Rochester 3, N. Y.

Rochester Mfg. Co., Inc.
100 Rockwood St.
Rochester 10, N. Y.

Rochester Products
1000 Lexington Ave.
Rochester 3, N. Y.

Roller Bearing Co. of America
Whitehead Rd.
Trenton 3, N. J.

Rubberset Co., Inc.
900 Passaic Ave.
E. Newark, N. J.

Sacramento Air Material Area
McClellan Air Force Base
McClellan, Calif.

Sacramento Signal Depot
Sacramento, Calif.

St. Mary's Hospital
Pierre, So. Dakota

San Antonio Air Material Area
Kelly Air Force Base, Texas

San Bernardino Air Material Area
Norton Air Force Base, Calif.

Sears, Roebuck & Co.
Administrative Office, Eastern
Territory
Philadelphia 32, Pa.

Shuron Optical Co., Inc.
Box 273, 172 Lyceum St.
Geneva, N. Y.

J. E. Smith Co.
836 Leadnhall
Baltimore, Md.

Southwest Grease & Oil Co.
Wichita, Kansas

Sperry Gyroscope Co.
Great Neck, L.I., N. Y.

Standard Packaging Corp.
551 5th Ave.
New York 17, N. Y.

Stavid Engineering, Inc.
Highway 22
Plainfield, N. J.

Stewart-Warner Corp.
South Wind Plant
Indianapolis, Ind.

Stokeley Foods, Inc.
Lawrence, Kansas

Stow-Davis Co.
Grand Rapids, Mich.

Stromberg-Carlson
100 Carlson Rd.
Rochester 3, N. Y.

Stupakoff Ceramics Co.
Latrobe, Pa.

Synthane Corp.
Oaks, Pa.

Taylor Instrument Co.
95 Ames St.
Rochester 1, N. Y.

Television Associates
Pennsylvania Ave.
Manchester, N. H.

Textile Machine Works, Inc.
P. O. Box 940
Reading, Pa.

Thermoid Rubber Company
Trenton, N. J.

Thiebolt Aircraft Co.
4924 Hampden Lane
Washington 14, D.C.

Thompson Products, Inc.
23555 Euclid Ave.
Cleveland, Ohio

Timken Roller Bearing Co.
Canton, Ohio

Tip-Top Products Co.
1515 Cuming St.
Omaha, Nebr.

Titeflex, Inc.
Hendee St.
Springfield 4, Mass.

Town and Country Shoe Co.
Ambassador Building
St. Louis 1, Mo.

Alexander Ungar, Inc.
26 Water St.
New Brunswick, N. J.

U. S. Hammered Piston Ring
Company, Inc.
Railroad Ave.
Stirling, N. J.

U. S. Naval Air Station
San Diego, Calif.

U. S. Naval Construction Bn.
Center
Port Hueneme, Calif.

United States Pipe & Foundry Co.
3300 First Ave., North
Birmingham, Alabama

Vertol Aircraft Corp.
Morton, Pa.

Victory Engineering Corp.
16 Springfield Rd.
Union, N. J.

Vulcan-Hart Mfg. Co., Inc.
3600 North Point Blvd.
Baltimore, Md.

Walton Company
600 New Park Ave.
West Hartford, Conn.

Weinschel Engineering Co., Inc.
10505 Metropolitan Ave.
Kensington, Md.

Welin Davit & Boat Div.
Continental Copper & Steel
Industries, Inc.
500 Market St.
Perth Amboy, N. J.

Welding Engineers, Inc.
P. O. Box 391
Norristown, Pa.

S. K. Wellman Co.
Cleveland, Ohio

Westinghouse Air Brake Co.
Union Switch & Signal Division
Swissvale, Pa.

Westinghouse Corporation
Fairmont Plant
Fairmont, West Virginia

T. C. Wheaton Co.
Millville, N. J.

Wilcolater Company
1001 Newark Ave.
Elizabeth, N. J.

Wright Aeronautical Corp.
Woodridge, N. J.

APPENDIX B

Questionnaire and Accompanying Materials Mailed to

178 Firms

APPLIED PSYCHOLOGY CORPORATION

Date

XYZ Company
Main Street
Factory Town
U.S.A.

Dear Sir:

We have received a grant from the National Institutes of Health, for the purpose of conducting "a study of the applications of the principles of human engineering to the design of machines or workplaces used by the blind in industry."

I should be most grateful if your company can furnish us with the information on the enclosed forms.

If you would be interested in receiving a report of our study, please note this item on the questionnaire.

Thank you for your time and consideration.

Sincerely yours,

Robert B. Sleight, Ph.D.
President

REPRINT OF ARTICLE: HUMAN ENGINEERING

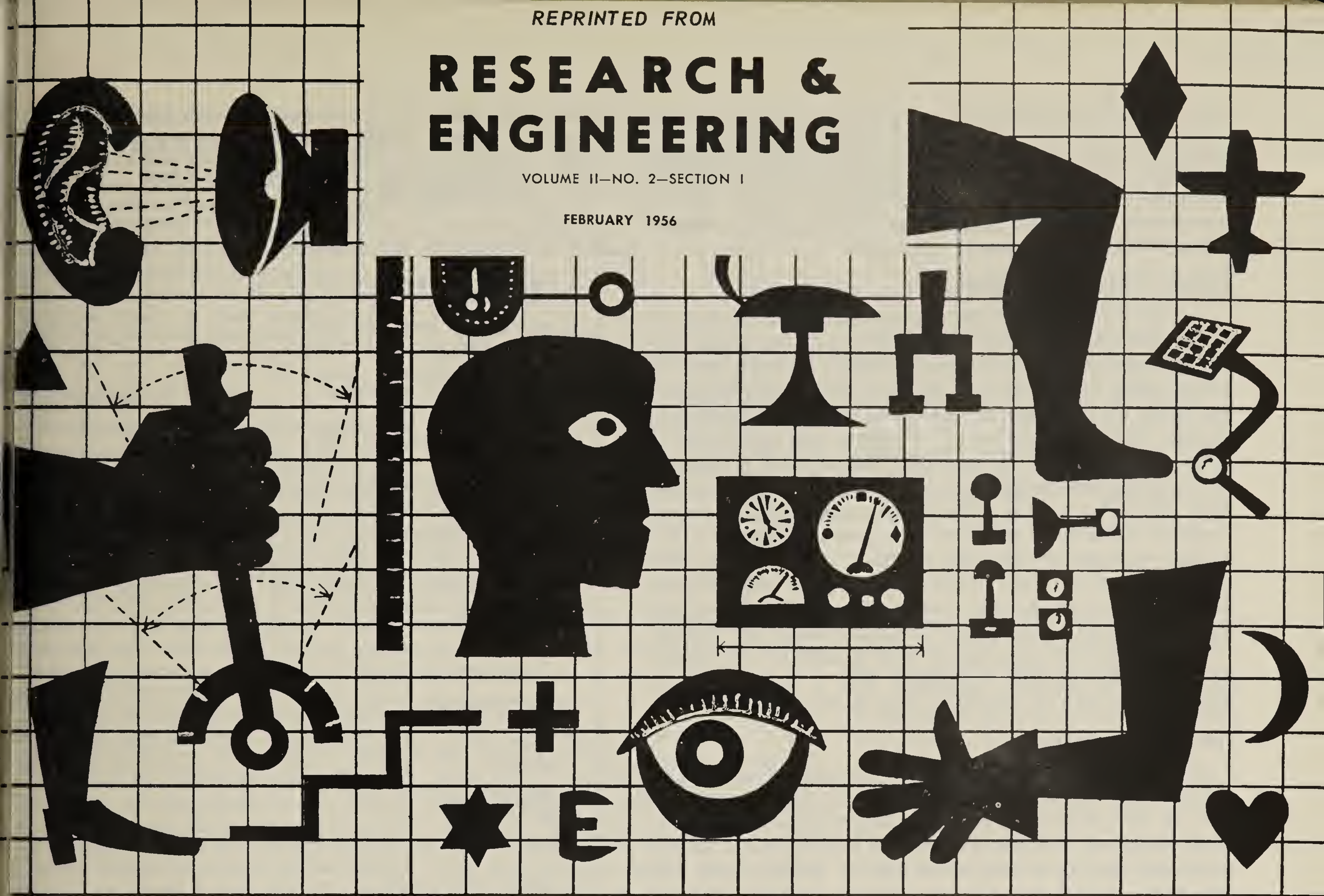
(Pages B3-B7)

REPRINTED FROM

RESEARCH & ENGINEERING

VOLUME II—NO. 2—SECTION I

FEBRUARY 1956



HUMAN ENGINEERING

In less than ten years Human Engineering has had a profound effect on development and design. Management's interest in this new science is shown by its queries: "What is Human Engineering?", "Can it enhance our profit position?", "How does it improve man-machine relationships?" Here are the answers.

ROBERT B. SLEIGHT
Applied Psychology Corporation
4113 LEE HIGHWAY, ARLINGTON 7, VA.

MAN HAS BEEN CONCERNED with the problem of designing equipment to suit his needs and capabilities ever since the first caveman selected and shaped a club to secure food or to protect himself. In selecting his club primitive man undoubtedly considered, perhaps in a nebulous, unverbalized manner, a number of factors which would go into making a good weapon for him—weight, grip size, balance and length. When Mr. Caveman had made his selection, the club was most suitable because it conformed to his particular body dimensions, his strength and to the purpose for which it was intended. Today most simple industrial products can be used with relatively little loss in effectiveness due to differences among users. But our industrial age is rapidly becoming more complex, and the equipment needed to maintain it is likewise becoming more complicated. Today more than ever before the machine must be tailored to the man. Such fitting of the machine to the man is one of the primary objectives of the practicing human engineer.

Consider the cockpit of a modern fighter. Instead of the "stick and throttle" arrangement of World War I planes, the jet pilot is confronted with arrays of instruments and controls in front, at both sides, and in some cases, behind him. He must frequently wear an altitude pressure suit which even in an uninflated condition severely hampers his mobility and reduces the amount of room in which he may move. Thus restricted in movement, the pilot yet has much to do and to observe; at the high speeds at which he flies he has very little time to see and act before a needed correction becomes an emergency or a crisis demanding ejection from the plane. A modern 1,000 mph jet airplane

will cover a distance of nearly one-half mile before the pilot will be able to make a simple reaction to an object appearing in the plane's path. Each instrument or piece of equipment used must be constructed to suit the pilot's capabilities, for a very narrow line exists between successful operation and disaster.

Human Engineering Appraisal

Equipment evaluation has always been a major task of the manufacturer. Seldom though has such equipment appraisal been done in a systematic fashion with all sorts of people using the equipment. Recently the human engineer has taken over the major responsibility for equipment appraisal. This trend is logical whenever the equipment is to be used in any way by a human. The principal techniques of evaluation are statistical tests in a typical use situation. Most often this means comparisons between Model A and Model B used over a period of time by typical persons. The human engineer is especially qualified to specify the test element which has been referred to above as "typical". He knows too how people vary, and he therefore specifies how many test runs are necessary to obtain stable test results.

Occasionally the experienced user, guided by the human engineer, can evaluate equipment with a rating scheme. Such a scale may be similar to that in Fig. 1.

The Human Body

Any equipment which man is to use must be designed to suit his body measurements. Despite the fundamental nature of this statement and its tacit acceptance by equipment designers, detailed and precise measurements of human body size have been made only in recent years. Too frequently equipment has been built to suit the technical requirements of the designers rather than the needs of the widely varied potential users.

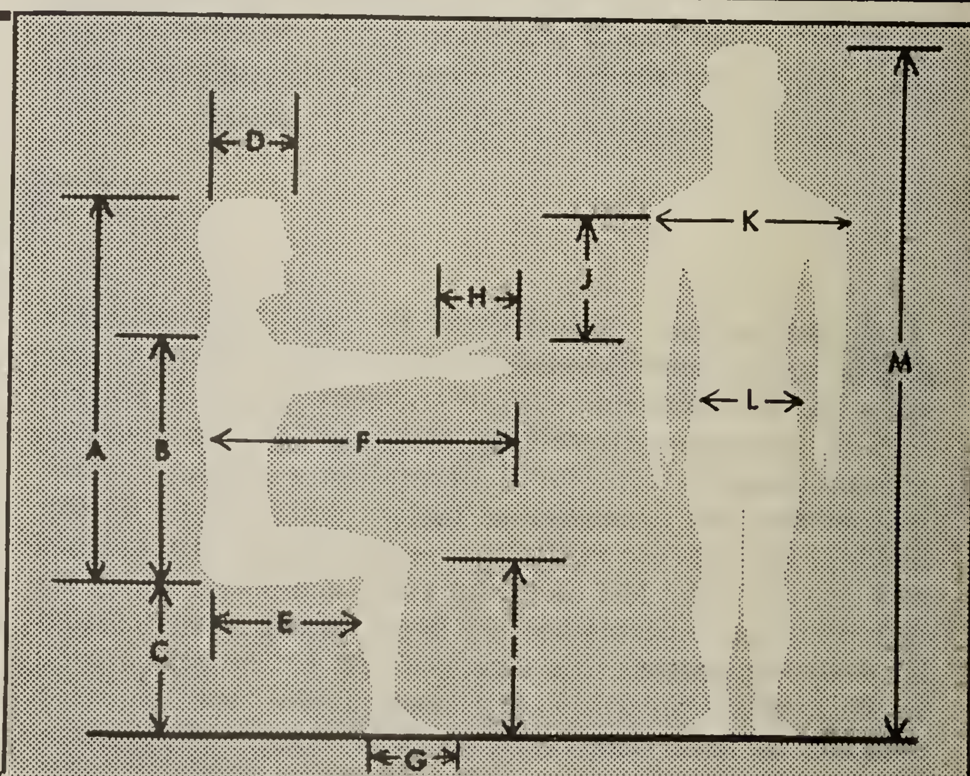
The fallacy of thinking in terms of an "average" man has also led to poor design characteristics from the standpoint of human body size. By definition the average man is one who is neither tall nor short, fat nor slim.

(FIG. 1) **HOW WOULD YOU RATE IT?**

EVALUATION CHARACTERISTIC*	GOOD 1	2	FAIR 3	4	POOR 5	NA
1. PORTABILITY. (Is it easy to move?)	☐	☐	☐	☐	☐	☐
2. DURABILITY. (Can it be used for a long period?)	☐	☐	☐	☐	☐	☐
3. MAINTENANCE EASE. (Can the unskilled repair it?)	☐	☐	☐	☐	☐	☐
4. OPERATING EFFICIENCY. (What is the energy and time needed?)	☐	☐	☐	☐	☐	☐
5. INTERPRETABILITY. (Can information about its operation be obtained readily?)	☐	☐	☐	☐	☐	☐
6. OPERATOR FATIGUE. (Does its use tire, require concentration?)	☐	☐	☐	☐	☐	☐
7. USER REQUIREMENTS. (Does it require high degree of skill?)	☐	☐	☐	☐	☐	☐
8. ENVIRONMENTAL DEMANDS. (Does it require special conditions for use and for storage?)	☐	☐	☐	☐	☐	☐
9. COMPATABILITY. (Can you use other equipment at same time?)	☐	☐	☐	☐	☐	☐
10. VERSATILITY. (Can it be used for several or only a few jobs?)	☐	☐	☐	☐	☐	☐
11. ACCURACY. (Is it precise or thorough?)	☐	☐	☐	☐	☐	☐
12. RELEVANCE. (Does it fulfill a basic need?)	☐	☐	☐	☐	☐	☐
13. SIZE. (Suited to user and job?)	☐	☐	☐	☐	☐	☐
14. WEIGHT. (Suited to user?)	☐	☐	☐	☐	☐	☐
15. APPEARANCE. (Is it appealing?)	☐	☐	☐	☐	☐	☐
16. SPEED. (Does it operate or do a job quickly?)	☐	☐	☐	☐	☐	☐
17. COST. (Is cost reasonable?)	☐	☐	☐	☐	☐	☐
18. SAFETY. (Is it hazardous to the user or others?)	☐	☐	☐	☐	☐	☐

** Special rating schemes are often used for special equipment.*

		AVERAGE	90% BETWEEN
A.	erect sitting height	35.9	33.8— 38.0
B.	trunk height	23.3	21.3— 25.1
C.	seat height	19.0	17.5— 20.5
D.	head length	7.8	7.3— 8.2
E.	seat length	18.9	17.3— 20.5
F.	arm reach	34.6	31.9— 37.3
G.	foot length	10.5	9.8— 11.3
H.	hand length	7.5	6.9— 8.0
I.	knee height	21.7	20.1— 23.3
J.	shoulder-elbow height	14.3	13.2— 15.4
K.	shoulder width	17.9	16.5— 19.4
L.	seat breadth	14.0	12.7— 15.4
M.	standing height	69.1	65.1— 73.1
	WEIGHT (lbs)	163.6	132.5—200.8



All examples of human engineering noted in this article are based on studies conducted by staff members of the Applied Psychology Corporation.

Fig. 2. Male Body dimensions. The comfort of an operator is a question of efficiency as much as it is of luxury. Although the design of a workspace on the basis of average dimensions is better than a hit or miss design, the inclusion of adjustability in chairs, etc. will increase the efficiency of odd-size operaters and reduce the problem of selection.

He is the middle man; consequently half the population would be above average, half below. A few people will be extremely large, a few extremely small; for these, custom made equipment will be needed. For the most part it is impractical to design equipment general enough to suit every man; therefore, designs are usually made to suit 90% of the people. Fig. 2 illustrates many of the anthropometric measurements of concern in equipment design.

The Human at Work

Environment: The human engineer is not only interested in what the man works with but where he works. Environmental conditions can govern to a surprising extent the efficiency with which machines are utilized. One of the environmental conditions arising from man's quest for labor saving devices and high speed mobility has been air pollution and contamination by toxic gases resulting from incomplete fuel combustion. In most cases safeguards have been established where large, lethal concentrations of toxic gases are known to exist. Fig. 3 shows carbon monoxide concentrations in relation to effect on the human. The human engineer is particularly concerned with the area (indicated by the question mark) which has not yet been thoroughly investigated by the physiologists and the medical specialists. This is the area of low concentration in which the human will experience such adverse effects as distraction, lowered morale, slowed reaction and irritation, all contributors to decreased efficiency.

Let us look at another activity of the human engineer relevant to the environment. The human organism is remarkably adaptable to grossly changing and physically stressing environmental conditions. This adaptability, or capacity for performance under adverse environmental conditions, sometimes means that the designer overlooks the need for optimizing the work environment. Men can and have performed in extreme cold and extreme heat; men can work and fight in the desert or arctic. But when other stressful conditions, such as poorly designed equipment, exist in conjunction with adverse environmental conditions, the possibility of seriously impaired performance, e. g. an incorrect or delayed reaction, is greatly increased.

Below is a brief summary table of an appraisal done to guide research planning. The particular study upon which the guide is based was concerned with delineating the needs for human factor studies relevant to design of equipment for use in the desert. Many of the facts and principles on this problem, as with numerous others in the field of human engineering, are available for application. Still, certain experimental studies and many actual field investigations are needed. Human engineers are particularly qualified to conduct such studies because of their practical knowledge of human perception.

Workspaces

The workplace in the airplane: Current day aircraft, because of the intricacy and multitude of controls and displays, necessitate careful consideration of human body size. Fig. 4 shows the areas which can be used best for locating those controls operated by a seated man, such as the airplane pilot. In this model 90% of male fliers, even while wearing restricting clothing and survival gear, will be able to reach and actuate controls if these controls are located in the areas shown. This illustration also makes a distinction between those areas where controls can be reached easily (optimum control area) and those areas where reaching is difficult (maximum limit of work area).

The area near the operator is the optimum one; both easy grasp and vision are possible here. The surrounding area can be reached by a full hand stretch, but portions of it will be beyond the field of vision. Visual displays should not be more than 60° from the straight-ahead line, but will be readable if 28″ from the eyes.

The workplace in a truck cab: Motor vehicle accidents are one of the most serious problems facing present day society. Among the many and varied causes of such accidents is poor design of the interior of the vehicle, which often makes operation difficult. Motion pictures were made of experienced drivers operating trucks over a standard test course. This film was then read, one frame at a time, to find out which cab designs were bad. If, for example, a truck driver has to lean far forward in order to operate the gearshift lever, stretching draws him out of position so that he cannot steer quickly and accurately. Such awkward positions can contribute to accidents in a critical or emergency situation. Human engineers have studied the brakes, windshields and instrument panels of motor vehicles as well as other design features and have made recommendations for improving design deficiencies.

Industrial inspection: Despite advances in machine inspection much industrial inspection is still done by the human eye. Frequently the inspection by eye is done as the item moves by on a conveyor belt, so that the task is to see objects while they are in motion.

In such a situation when improvement of quantity and/or quality of inspection is desired, one is immediately confronted

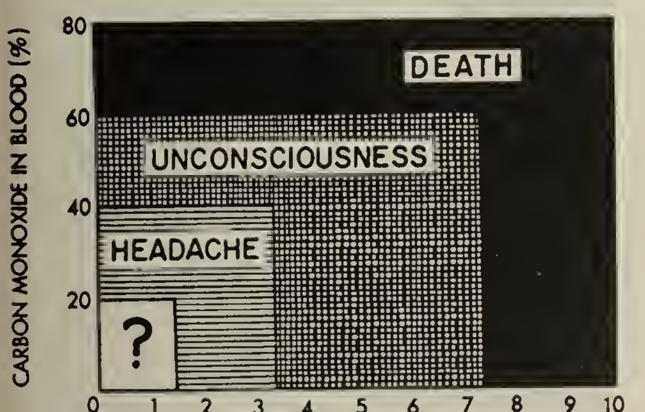


Fig. 3. Effects of toxic gases. Even a small concentration of a toxic gas, such as carbon monoxide, will affect the living organism. The human engineer is especially concerned with the small concentrations (such as the ? area) because of the possibility of decreased perception and slowed reaction which can mean inefficient and hazardous operation when the man is under stress or the equipment is complex.

TABLE I: SUMMARY OF SURVEY FINDINGS AND RECOMMENDATIONS ON HUMAN FACTORS IN THE DESIGN OF DESERT EQUIPMENT

AREA OF INQUIRY	FINDING	RECOMMENDATIONS
1. Desert Conditions	Extreme highs of temperature, atmospheric perturbations; difficult terrains.	Need data on desert conditions in form useful to human engineer; need more data on brightnesses, atmospheric conditions.
2. Physiological Performance	Functioning is near normal for acclimatized persons; limits of bodily distress more easily reached.	
3. Psychophysical Performance (a) Vision	Brightness, atmospheric perturbations. terrain adversely affect ability to see; precise effects not known.	Need research on vision specific to desert conditions.
(b) Audition	Effect of desert on hearing largely unknown; difficulties in communication reported; auditory mirages.	Research on best auditory signal; effects of atmospheric conditions, terrain.
(c) Psychomotor, mental	Performance not adversely affected by high atmospheric temperatures as such, except when combined with humid atmosphere.	
	Heated controls and surfaces exceed pain thresholds.	Research on ability to perform as function of control temperature.
4. Human Engineering in the Desert	Reports of excessive compartment temperatures, heated control surfaces, poor ventilation, poor visibility, cramped seating, and irritations from dust and sand.	Continued human engineering efforts on desert equipment. Use of human engineering services in desert evaluations.
	Possible morale problem.	Study of morale factors in equipment operation.

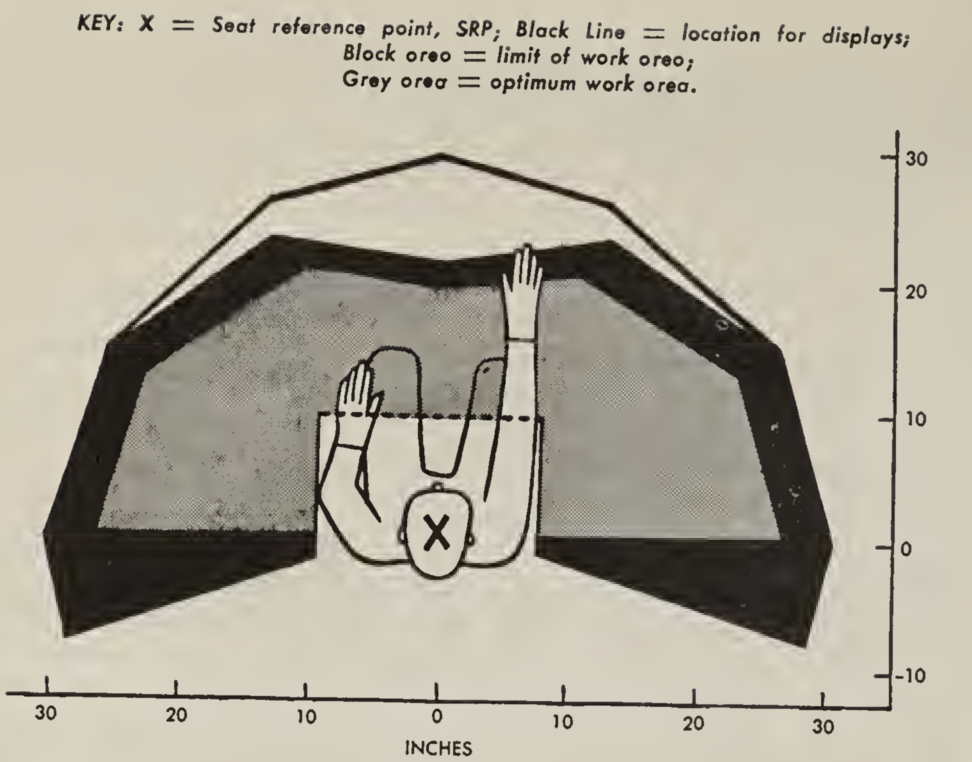


Fig. 4. Control location in an airplane. Controls should not be located too near or too far from the operator. Displays should be close to the line of sight.

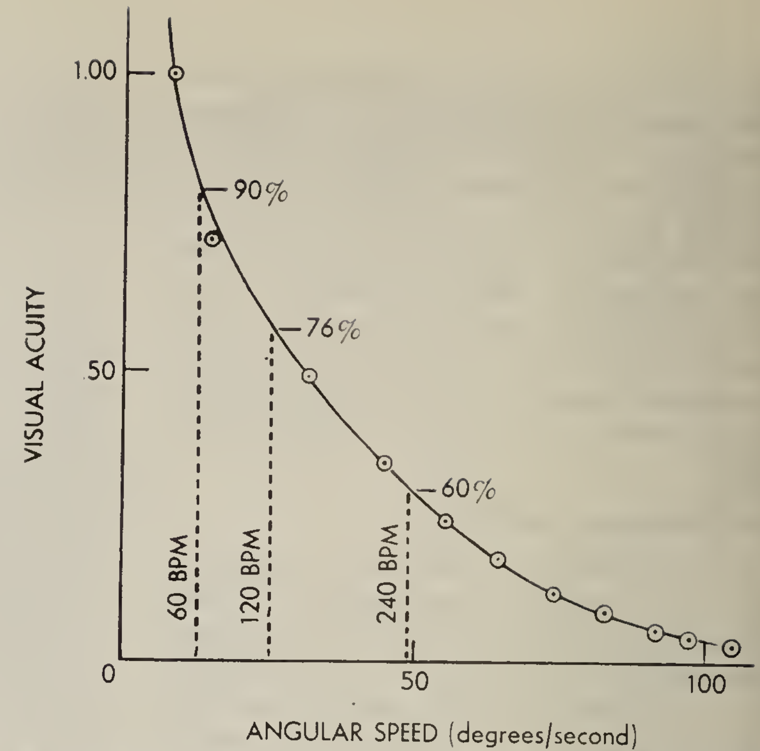


Fig. 5. Visual acuity as a function of target speed. Note that doubling from 60 BPM (bottles per minute) to 120 BPM means a 14% loss in inspection, but doubling again to 240 BPM means only another loss of 16%. However, because only a small percentage of the bottles formed are defective, this decrease in inspection will result in very little quality loss.

with the problem of visual acuity of the human eye for seeing moving targets. An analysis of the job of glass bottle inspection was conducted for the Owens-Illinois Glass Company. (In this company this job occupies 25% of the company's personnel and costs several million dollars a year). By relating the speed of target (i.e., defects like bubbles and cracks) movement, the typical percentage of defective bottles and the visual acuity, it was possible to demonstrate that a 100% quantity increase would result in less than 1% increase in defective bottles passed as o.k. Improvement in lighting, bottle rotation, training and morale would more than compensate for the very small quality loss due to increasing the number of bottles per minute passing in front of the inspector.

Dials: The complexity of modern equipment demands that more information be available to man than may be obtained by direct use of the senses. As a result the operator of equipment must have information about the nature of his equipment performance presented to him in the form of relatively abstract displays. Usually these displays are things he sees, but they can also be what he listens to or what he feels; for example, flying the beam or reading Braille.

Very often one wishes to know quickly and in numerical terms what is happening. How fast is the car going? At what altitude is the plane? What is the temperature? Human engineers have attempted to redesign dials so that these questions may be answered with greater accuracy than ever before. Fig. 6 shows the results of a visual display study done to determine the best kind of instrument dial for presenting quantitative information about equipment operation. The small open window or counter type dial will give the highest reading accuracy.

Numbers: Quick and accurate readings of dials are often necessary. In our highly literate society this frequently means reading numbers. The seriousness of misreading numbers cannot be underestimated; for example, reading an altimeter as 530 feet when the actual altitude of an airplane is 350 may very well result in a crash, or reading a pressure gauge as 50 instead of 80 may mean an expensive explosion. When one thinks of the possibility of changing the design of some of our numbers he is immediately confronted with the problem of the familiarity of people with existing numerical forms. Therefore, although a really optimum design might be radically different, such changes would not be practical in view of probable public resistance to accepting them. The modified numbers shown in Fig. 7 differ only slightly from common forms. These digits have been thoroughly tested from the standpoint of accuracy and speed of reading. They are not as likely to be confused as the more commonly used digit forms where numbers such as 3, 5 and 8 are often misread. You may wonder where the number "1" is. Because it is a simple straight form, it is so legible that it didn't warrant experimental study.

Symbols for complex displays: Suppose you wanted to symbolize some large unit in the form of compact figures. You might think of using letters and numbers, or words and abbreviations. The use of various geometric shapes is a logical supplement to the symbolization by these means. A study was conducted using a large number of geometric configurations to ascertain which could be most readily discriminated, i.e., which ones were easiest to pick out of a large mass of geometric figures. All of the figures tested use the same

Percentage of Accurate Reading

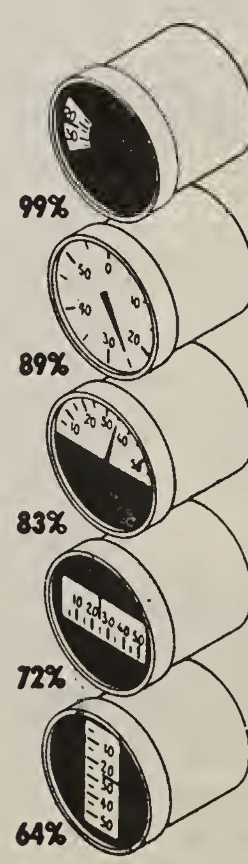


Fig. 6. Dial reading accuracy in relation to dial shape. There are not only differences in how well men can read, but also differences in how accurately dials of different designs can be read. It is often more efficient to select the easiest dial to read than to attempt to train the man.

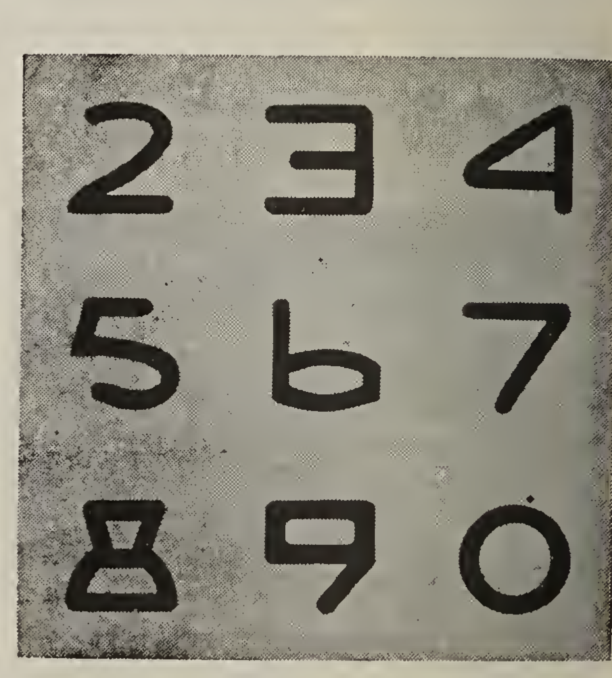


Fig. 7. Most readable numbers. Line width, spacing, proportion and form have been experimentally studied. These numbers will be seen at greater distance and with less confusion than most common styles.

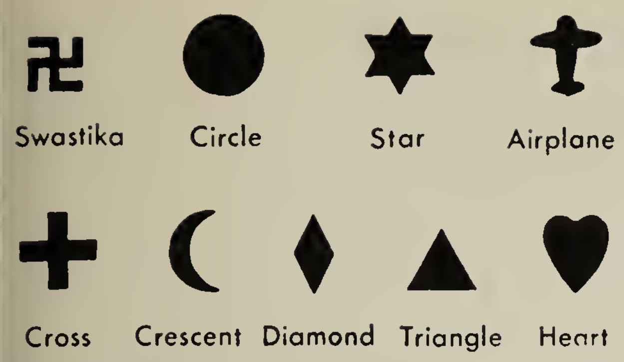


Fig. 8. Some highly discriminable geometric forms for identifying visually. These forms may be useful on plotting boards, status boards, etc.

amount of space; in other words they can all be inscribed in a common circle. Out of some 21 forms tested those 9 illustrated in Fig. 8 were found to be most easily and most quickly identified. Although there naturally would be a certain amount of initial learning required to understand the meaning of each symbol, they nonetheless could be of great value for use on plotting boards, status boards and electronic screens.

Directional indicators: If you have driven an automobile often, you have undoubtedly encountered directional indicators on highway signs which were difficult to see at a distance. Fig. 9 shows some "good" and "bad" directional indicators.

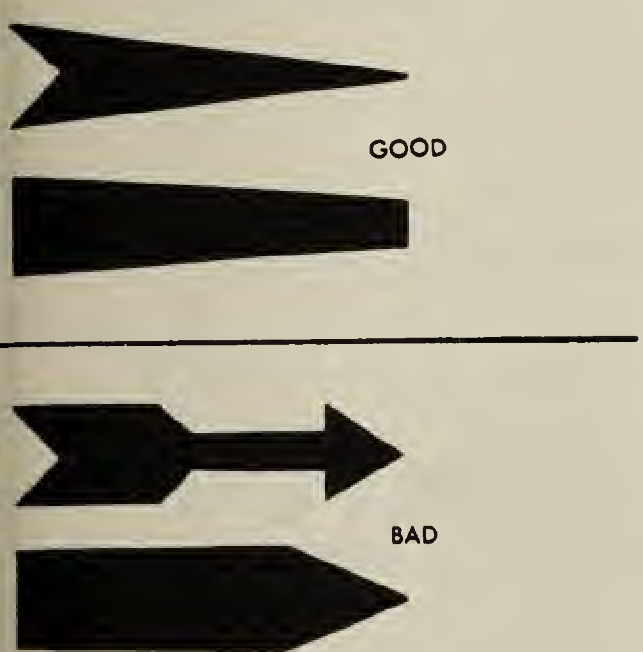


Fig. 9. Arrows for showing directions. Something can even be done about the high automobile accident rate. It has been found that the commonly used signs indicating direction are not seen as clearly as the two top directional indicators.

These have been carefully tested, and the two noted as "good" have been demonstrated to be readable at nearly twice the distance of the poorly designed indicators. Here is an instance where the human engineer has contributed to both safety and design.

Tactual displays: Despite the large amount of information obtained by the normal human being of things surrounding him by means of the tactual sense, very little use has been made of this sense in helping man control equipment. Fig. 10 shows some letters, numbers and geometric forms which we have determined experimentally to be identified easily by means of finger touch. As in the study with visually perceived forms these tactually perceived forms all covered equivalent area. Experiment determined that these raised forms could be "read" with nearly perfect accuracy even by untrained people with a mere touch of the finger tip. Possible specific application of these forms in cases where the operator's eyes are occupied elsewhere might be on push buttons on industrial machinery, on airplane cockpit controls and on dashboard switches of the ordinary automobile. Also, such tactual cues can speed up learning and relieve the burden on other sense modalities and thus promote better overall human efficiency.

Readability

The complexity of much modern equipment has led to nearly incomprehensible instructions on how to use and maintain such equipment and devices. The human engineer, because of his interest in equipment design from the human factors standpoint and his knowledge of the learning process, has logically become involved with the nature of instruction manuals and similar materials. In many cases inefficient or hazardous operation of equipment can be attributed to lack of understanding of instruction or maintenance manuals. These manuals, frequently prepared by design engineers intimately acquainted with all of the intricacies of the equipment, may be unintelligible to the operator or maintenance man. In some cases an analysis of the operation and maintenance technical manuals for certain trucks gives evidence of the belief that most of the material would be classed as "difficult" and it was in fact found to be largely incomprehensive to those for whom it had been written. An original excerpt, as written in a truck technical manual, and revised (but perhaps not ideal) statement with improved readability are presented below.

"175. Leakage Tests

A. General

The Hydra-Matic transmission does not "use" or "burn" oil, as an engine does. Consequently, any appreciable loss of oil from transmission is due to leakage and cause must be determined and condition corrected to avoid damage to transmission. Conversely, if transmission fluid level raises, cause is due (sic) leakage into transmission of engine coolant.

B. Oil Leakage

From underneath truck, carefully examine rear end of transmission case, at propeller shaft flange, for evidence of leakage."

A revision, employing several of the principles for increasing readability, might be as follows:

"175. How to Test for Leaks

The Hydra-Matic transmission does not BURN oil, but it may LEAK. If you see the oil going down, look for a leak. Then get it fixed as soon as you can. If you do this, you will help to avoid damage. If you notice TOO MUCH fluid see if water has leaked in.

Where to Look for Leaks

First you go underneath the cab of the truck and look at the back part of the TRANSMISSION CASE. There you will see the propeller shaft flange. Look there for spots where OIL is leaking out."

Fig. 10. Letters, numbers and symbols for tactual displays. These raised characters could be "read" by touch.

Will We See More of Human Engineering?

Although human engineering as a specialty is less than ten years old, its effect has been profound. Besides the kinds of studies and applications already illustrated, human engineers have been concerned with training devices, analysis of systems, picture quality, effect of color on safety and performance, light levels for work, effects of noise and vibration, voice communication, and many other aspects of modern life. To date human engineering has been applied mainly to military equipment and military jobs as in the following: cameras, fire control radar, trucks, telephones, aircraft, clocks, airway traffic control devices, tanks, rifles, road signs, computing machines, status boards, maps, plotting boards, synthetic trainers, navigator equipment, missile controls and stoves.

There can be little doubt that this list will continue to grow as more and more industrial people see the need for considering the human element. The day may soon be here when the customer will ask—"Is it human engineered?" Workers may ask about their jobs—"When is my workplace going to be human engineered? Is my machine human engineered?"

Human engineering of products, machines and workplaces is not an industrial luxury; it is instead a means to satisfaction, safety and increased production. ✖

A NOTE ABOUT

THE APPLICATION OF HUMAN ENGINEERING TO THE WORK OF THE BLIND

Modification in the design and placement of tools, materials and workplaces is often an essential step in the effective use of blind employees in industry. Since the human engineer specializes in adapting machines to the individual needs and working methods of each operator, he is especially qualified to perform this function. He can manipulate the machine and the workplace so that regardless of the capabilities or limitations of the operator, the result is a smooth-working man-machine system in which tasks are carried out safely and efficiently with a minimum of instruction and supervision.

Below are listed examples (written in very general terms) of the ways in which changes may be made to aid the blind employee in an industrial situation.

Example 1. On a machine having several controls (knobs, switches or levers) which perform different operations, the human engineer might:

> shape-code the control handles (i.e., make the handles of the various controls distinctive in shape)
>
> place raised letters, numbers, or other symbols on control handles
>
> move the controls farther apart
>
> change some switches or levers to foot controls
>
> change the direction of operation of some controls (i.e., forward and back, right and left)

Example 2. Where it is necessary to thread a needle, as in a sewing task, the blind operator can use a needle (already on the market) which can be threaded by the tactual sense.

Example 3. Lights used as warning devices on machines may be replaced by tonal or touch devices.

Example 4. A coded system of tones or other auditory devices may be substituted for the dials on a counting machine.

Footnote: The accompanying reprint may help you to see how these examples fit into the larger framework of human engineering. We hope it will aid you in understanding the type of information for which we are asking on the questionnaire.

Applied Psychology Corporation

[illegible]

HUMAN ENGINEERING THE WORK OF THE BLIND

PLEASE: Complete the blanks below carefully and conscientiously. Your answers may greatly assist the blind.

Name of firm

____

Address

____

____

Name of person completing questionnaire

____

Title or position

____

If your firm is interested in a final report of our study, please indicate here to whom it should be addressed:

Name _________________________ Position _____________

Address ____

____

I. Number of blind workers employed by firm. (Circle)

None 1 2 3 4 5 6 7 8 9 10 20 30 40 50

Do you know of other firms which employ the blind?

_____________________ _____________________

_____________________ _____________________

_____________________ _____________________

(If your plant employs no blind, please return this form, along with any comments you may have.)

Applied Psychology Corporation

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

II. Blind personnel are engaged as follows:

A. Machine operation

Kind of machine	No. Employed

B. Assembly

Item assembled	No. Employed

C. Inspection

Item inspected	No. Employed

D. Sorting

Item sorted	No. Employed

E. Packing, wrapping, crating

Item handled	No. Employed

F. Other jobs. Please describe in a few words.

1. ____

____

No. Employed________

2. ____

____

No. Employed________

3. ____

____

No. Employed________

4. ____

____

No. Employed________

III. Probably some of your blind employees, their supervisors, or others, have made changes or innovations in the blind workers' equipment or environment in order to increase efficiency and/or ease of performance. Will you please tell us briefly about such improvements? (Please try to give at least three examples in the space below and on the succeeding page.)

IV. Describe in some detail what, in your opinion, was the most outstanding or significant change or adaptation that was made.

V. One additional matter --

We are anxious to visit as many plants as possible for an on-the-spot coverage of the work of the blind.

May a representative of the Applied Psychology Corporation visit your plant?

Yes_______ No_______

With whom should arrangements for a visit be made?

Name

____

Address

____

____

Telephone Number

____

Applied Psychology Corporation

APPENDIX C

Individuals, Agencies and Institutions Contacted

Additional Activities

In addition to the work done at the libraries in Washington, the information obtained by questionnaire, and the personal visits to specific industries, an effort was made to learn about blind industrial workers and their jobs through other methods. The letters to the State Commissions for the Blind have been mentioned previously. Various printed materials were secured from such organizations as the American Foundation for the Blind. A fair sized file of current newspaper and magazine clippings was accumulated. Numerous telephone calls were made to area industries which had been indicated by various sources as blind employers (none were), and interviews were obtained with the following individuals and agencies:

Mr. Charles G. Ritter
Head, Special Services
American Foundation for the Blind, Inc.
15 West 16th St.
New York 11, N. Y.

Mr. Irving Schloss and Dr. R. Thompson
Blinded Veterans Association
3408 Wisconsin Ave., N.W.
Washington, D. C.

Mr. James Zink, Plant Manager
The Blind Work Association
56 Water St.
Binghamton, N. Y.

Mr. J. Arthur Johnson
Columbia Lighthouse for the Blind, Inc.
500 9th St., N.W.
Washington, D. C.
(now located at 2021 14th St., N.W.)

Mr. Vito Proccia and Mr. Herbert Dern
Electronics Research Laboratory
Department of Electrical Engineering
Columbia University
632 W. 125th St.
New York City, N. Y.

Mr. Hiram Chappel
Office of Vocational Rehabilitation
Division of Services for the Blind
Department of Health, Education and Welfare
330 Independence Ave., S.W.
Washington, D. C.

Dr. Michael Supa
Supervisor of Handicapped Personnel
International Business Machines Corporation
Endicott, New York

Mr. C. Warren Bledsoe
Physical Medicine Rehabilitation Division
U. S. Veterans Administration
Vermont Ave. and I St., N.W.
Washington 6, D. C.

Mr. Jerry Wise
Veterans Benefits Center
Vermont and I St., N.W.
Washington 6, D. C.

These personal calls and visits were made with several objectives in view. It was anticipated that the people seen would be cognizant of research projects currently underway or proposed, aware of unpublished work, or reports in press, and would be a source of additional names for future contacts. Other information sought during these visits included names of industries employing blind, or sources for this data, and any examples of human engineering in the workplace of the blind which had been personally observed. On one of these calls (to a Binghamton, N.Y. factory), a large number of blind employees were observed at work in a small industrial plant. This was at the Blind Work Association, a non-profit voluntary agency serving the blind people in six New York state counties. Approximately 70 persons are employed in its workshop; between 80 and 85 per cent of these individuals are legally blind or visually handicapped. Since 1942 the workshop has been doing

subcontract work for local commercial firms and for the government.

In the $2\frac{1}{2}$-story building the writer observed approximately 70 blind personnel working in quiet comfortable surroundings. Operations being performed included control panel assembly, binder post panel assembly, terminal block assembly, packaging, sewing (towels, pillowcases, and dish cloths) and weaving.

The visit there yielded a concrete illustration of redesign on a specific job to make better performance possible by a blind individual. The change was in the post panel assembly operation, where a tapered cone, used to guide the spring loop on to the post, had been substituted for a hook. Little extra expense was incurred in this modification, and it also helped prevent material damage which had occasionally occurred in use of the hook.